THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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COMPLETION OF THE BOILER CODE

A SIGNAL event for the boiler industry and one that means much to the field of power production in general, was the completion of the report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for Care of Same in Service, and its presentation to the Council of the Society on February 13, 1915. Its approval by the Council—the governing body of the Society—and the authorization granted for immediate printing of the report as a Boiler Construction Code marks a new era in the manufacture of steam boilers, and it is hoped, will prove the inauguration of a movement of considerable importance for the protection of human life and property. The benefits that will accrue from an economical standpoint, when the rules for construction embodied in the new Code are generally put into effect, are far-reaching, and will affect alike the manufacturer and the user of boilers.

The work involved in the final revision of the Code was one of the most strenuous and trying committee undertakings ever carried out in the history of the Society. As stated in the February issue of The Journal, the work of revision began on December 15, 1914, and was carried on continuously without interruption until February 3, 1915, covering a period of nearly eight weeks of the most exacting and painstaking work. The Boiler Code Committee worked constantly in conference with the Advisory Committee which had been appointed in December and the sessions, which were both investigative and judicial in character, were marked by a peculiarly intense interest of the committee members and the most unusual display of energy. The daily sessions lasted usually throughout the day and until midnight and the attendance was usually a majority which is a matter worthy of note when it is considered that the committee members came from all parts of the country and some of whom were in constant attendance for the entire seven weeks. A notable feature of the final revision was the amount of research work involved, several series of tests having been carried out by members of the committee to check and establish the authenticity of the rules and formulae embodied in the Code.

The work of the Committee, as previously stated in The Journal, was confined to rules for construction of steam boilers only, all references to "other pressure vessels" and to laws and matters of legislation having been omitted. The result of the work of revision of the construction rules was the division into two parts, one for new installations and the other for existing installations, and following this was provided an appendix in which were placed the rules, examples, illustrations, references, and data that were in nature supplementary to the rules. As now laid out, the rules for existing installations (Part I) covers all details of construction of new steam boilers and the rules for allowable working pressures upon them, the details being referred to in the following order: Materials of construction, including the material specifications, maximum allowable working pressures, boiler joints, braced and stayed surfaces, combustion chambers, tubes, riveting and calking, manholes and handholes, safety valves, water and steam gages, and fittings and appliances. At the end of Part I is a section devoted to heating boilers, in which the above order of subjects is also adhered to. In Part II which is devoted to existing installations, the same order of subjects is followed, although less complete and exacting in details.

The text of the Code in its revised form was printed in the form of printer's galley proof and sent to each member of the Council of the Society, as well as to each member of the Boiler Committee and the Advisory Committee for final proof-reading, on February 3, ten days before the Council meeting on February 13. At the Council meeting on this latter date at which the whole Boiler Committee was invited into conference, the report was approved by the Council in full, as finally revised, and was ordered to be printed as soon as possible for general distribution; and pamphlet copies are being issued as a preprint of the

Transactions of the Society. Following the approval of the report, action was taken by the Council commending the Boiler Committee and the Advisory Committee for the heroic work that it had carried out in such a painstaking and careful manner and expressing the gratitude and appreciation of the Society to the enlarged Committee for the great work it had done for mankind.

The next step taken by the Committee was a careful proof-reading of the entire report for typographical errors and the preparation of the Code for final printing. It is now being issued in pamphlet form as above mentioned, at $1.00 per copy to members and $1.50 to non-members. Later the Code will be distributed to the entire membership.

It is pleasing to note that the Code is finding immediate application. The State of Indiana is at this time considering the matter and it is very probable that an amendment will be passed by the legislature rendering the former Indiana boiler code optional, with the proviso that the A.S.M.E. Code may be used for boiler construction in place of the present State code if desired. The Ohio State Boiler Board has the new Code under consideration and it is possible that it will be adopted in place of the boiler code now in force in that state. In Wisconsin the Code will probably take immediate effect as a result of an action of the Industrial Commission of Wisconsin taken last year looking forward to the A.S.M.E. Code before it was completed; while a preliminary set of boiler rules was put into effect in that state the first of this year, provision was made for their replacement by the A.S.M.E. Code as soon as finished.

With the completion of this great work, considerable interest attaches to the originators of the movement, the committee of seven members, appointed in 1911. The choice of these members represents the exceptional wisdom and foresight of the officials of the Society in their concern that all the various branches of the industry should be represented. John A. Stevens, a consulting engineer of extended power plant experience who was appointed chairman, offered the advantages of his experience in formulating the Massachusetts code, the first state boiler code that was put into effect in this country. R. C. Carpenter and E. F. Miller, professors of engineering, came as representatives of the steam boiler users; E. D. Meier and Richard Hammond brought in the fund of experience that only long experience in boiler manufacturing rendered possible; Chas. L. Huston was particularly valuable to the Committee as a steel plate manufacturer and an investigator in the scientific manufacture of iron and steel plate, and Wm. H. Boehm, an insurance engineer, brought to the Committee valuable suggestions as a representative of the field of boiler inspection and insurance. The frontispiece shows portraits of the above members of the original committee.

NOMINATIONS FOR OFFICERS OF THE SOCIETY FOR ELECTION IN DECEMBER 1915

The Constitution of the Society in C 47 provides among the Annual Committees:

"A Nominating Committee appointed by the President."

It further provides in C 48

A "Special Nominating Committee: Twenty or more persons entitled to vote may constitute themselves a Special Nominating Committee, with the same powers as the Annual Nominating Committee."

The procedure in the nominations for office is provided in the following By-Laws:

B-27 "A Nominating Committee of five members, not members of the Council, shall be appointed before February first of each year by the President. The Secretary shall publish the names of this Committee in the March issue of The Journal together with a request to the voting membership of the Society that they recommend to the Committee the names of eligible persons for the elective offices to be filled at the next election. This Committee shall deliver to the Secretary in writing between the first and the fifteenth of June the names of its nominees for the various elective offices next falling vacant under the Constitution, together with the written consent of each nominee. The names of the nominees for the various offices proposed by this Committee shall be published by the Secretary under the names of the Committee in the July issue of The Journal."

B-28 "A special Nominating Committee, if organized, shall on or before October fifteenth, present to the Secretary the names of its nominees for the elective offices next falling vacant under the Constitution, together with the written consent of each nominee. The names of the nominees for the various offices proposed by this Committee shall be published by the Secretary under the names of this Committee in the November issue of The Journal."

The President has appointed the following Nominating Committee:

Messrs. Edwin M. Herr, *Chairman*
Fred J. Miller,
Richard H. Rice,
Walter M. McFarland,
Edward C. Jones.

There are to be elected in December next
A President to hold office for one year
Three Vice-Presidents to hold office for two years
Three Managers to hold office for three years
A Treasurer to hold office for one year

Under the terms of By-Laws B-27 and B-28 the voting membership are requested to send to either or both of the Nominating Committees, in care of the Secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y., their recommendations of names for any or all of the elective offices to be filled at the next election.

These recommendations should be sent in early and not later than June 1st.

COUNCIL NOTES

At a meeting of the Council on February 13, 1915, the Secretary reported the appointment by the President of the Nominating Committee for Officers for 1916, to consist of E. M. Herr, Chairman, Fred J. Miller, Richard H. Rice, W. M. McFarland and E. C. Jones. The Committee on Administration, referred to in these minutes in The Journal for January, was announced to consist of R. M. Dixon, Chairman, L. P. Alford, George M. Basford, George M. Forrest and J. W. Roe.

The appointment of Park A. Dallis as Honorary Vice-President to represent the Society at the inauguration of Edward Kidder Graham as President of the University of North Carolina was approved.

George I. Rockwood presented personally to the Council a letter of invitation to the membership of the Society to be present at the Fiftieth Anniversary of the foundation of Worcester Polytechnic Institute as a school of industrial science. The invitation was accepted by the members of the Council. The letter appears in this issue of The Journal.

The report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for their Care in Service was presented and approved with the following resolutions:

RESOLVED: that the report of the Committee to formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for their Care in Service be received as presented in corrected galley proof and that it be printed in The Journal, and in the Transactions, and also in pamphlet form as part of the Transactions.

VOTED: that the Boiler Code Committee and the Advisory Committee be continued for one year as one committee, instead of separated as formerly, and to be known as the "Boiler Code Committee."

The Council expressed its appreciation of the unprecedented amount of time and work which the various members had given to the preparation of this report and for the splendid results.

It was voted that the report of the Committee on Standards for Cross-Sections and Symbols be received and printed in the Transactions and that the committee be discharged.

It was voted to accept the report of the Committee on Special Threads for Fixtures and Fittings covering rolled thread screw shells, which was presented by the Secretary, and that it be printed in the usual way and come up for discussion at the next Spring Meeting.

It was voted to approve amendments to the By-Laws relating to the Nominating Committee for officers and a Special Nominating Committee. The text of these appears in this issue in the notice of Nominations for Officers of the Society.

The following appointments on local committees were approved: Committee on Meetings in St. Louis, Edw. Flad, Chairman, George R. Wadleigh, F. E. Bausch, E. R. Fish, E. L. Ohle; as additional members on St. Paul-Minneapolis Committee, Max Toltz and H. F. Mueller.

CALVIN W. RICE, *Secretary.*

SIR WILLIAM H. WHITE MEMORIAL FUND

The movement recently started by the leading engineers of England to erect a suitable memorial to Sir William H. White, the eminent engineer, has culminated in the appointment of a Memorial Fund Committee. This Committee has decided upon a memorial tablet with medallion portrait, to be erected in the building of the Institution of Civil Engineers in London, as one form in which honor to Sir William will be made manifest. The members of this Society will be given an opportunity to express their interest by contributing to the tablet fund, and a committee has been authorized by the Council to secure subscriptions. This committee consists of Jesse M. Smith, Alex. C. Humphreys and Frederick R. Hutton, and subscriptions may be sent to the Secretary.

CONFERENCE ON SCREW THREAD TOLERANCES

On February 5, 1915, a large meeting was held in the rooms of the Society on the general subject of limits for the dimensions of the threads of screws and taps.

For more than two years this Committee of the Society, of which Mr. L. D. Burlingame is chairman, has been at work on the general subject of Tolerances For Screw Thread Fits, and the subject has had the detailed attention of a sub-committee consisting of Messrs. A. A. Fuller, Ellwood Burdsall and F. O. Wells. It was under the auspices of this sub-committee that the meeting of February 5 was called.

There were over forty in attendance, representatives of manufacturers of screws, taps and dies as well as the users, of such products and of organizations interested. A number of the largest firms in the country, both manufacturers and users were represented and also the engineering departments of both the Army and Navy.

Mr. Burlingame presided at the meeting. The committee had prepared an abridged report for distribution and there was a general discussion of limits of tolerances that would be recommendable with regard to pitch diameter, root diameter, outside diameter, lead and angle. Various opinions were expressed as to the desirability of specifying limits for more than one grade of work, i. e., a very close limit for the high grade of screw and a wide limit for screws to be used in rough work; also, whether differences in the specified limits should be made in the tap, or in the

screw. As a result of the conference, an Advisory Committee of three was appointed, consisting of Messrs. E. H. Ehrman, E. A. Darling and C. D. Young. This committee will confer from time to time with the regular committee upon the various questions which arise in this complex problem. Further, those who were in attendance at the meeting and others who have expressed their interest in the subject will be kept informed with regard to the progress of the work upon the report and, through their understanding of the situation as a result of the discussion at the meeting, should be in a position to render helpful suggestions.

This meeting is an example of the policy of the Society of conferring as widely as possible with representative men who are most vitally interested in any question affected by reports which are being formulated, with a view not only to securing the benefit of their experience, but the widest possible co-operation and unanimity of opinion. Meetings such as this tend to abolish misunderstanding and the consequent difficulties in establishing standards and greatly increasing the effectiveness of the work which the committees of the Society are accomplishing.

FIFTIETH ANNIVERSARY OF WORCESTER POLYTECHNIC INSTITUTE

Worcester Polytechnic Institute, Worcester, Mass., is to be congratulated on having reached the point where it is to celebrate the 50th anniversary of the granting of the charter for the school. The celebration will occur on Wednesday, June 9, during the commencement period. It is expected that the President of the United States will be present and through the attendance of prominent engineers and the representatives of various organizations the day will be made a celebration of the achievements of engineering and science as well as an anniversary of the Institute.

At the February meeting of the Council of The American Society of Mechanical Engineers, Mr. G. I. Rockwood presented personally a letter of invitation to the Society which was accepted with pleasure and is herewith transmitted to the membership:

Worcester, Mass.
Feb. 12, 1915.

TO THE COUNCIL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS,
29 W. 39th St.,
New York.

Gentlemen:

On the 9th of next June the Worcester Polytechnic Institute will celebrate the 50th anniversary of its foundation as a school of industrial science. The Trustees and Faculty have constituted the undersigned members of the society, who are also graduates of the Institute, a special committee to invite most cordially all members to visit the Institute on that day.

There will be an opportunity to meet great engineers and great men. Among others, Colonel Goethals has accepted our invitation. The President of the United States, who was the commencement orator twenty-five years ago, has expressed a desire to be present. In addition to the academic and social events, a meeting of engineers is to be held, papers by members of the society will be read, and interesting processes of manufacture at various engineering works will be open to inspection.

Above all, however, there will be the chance to study the character and facilities of the Worcester Polytechnic Institute itself, to see its commercial shops, foundry and power house in operation and observe at first hand the methods of a unique experiment in engineering education which has continued for nearly half a century, having as its object the development of engineers who even in their youth are substantially prepared to share in the responsibility of handling commercial engineering problems.

The Institute really stands almost alone in providing its graduates with a practical training in the scientific management of industry, a subject discussed so often and so forcibly by the membership of this society. The student not only studies the kinematics and statics of machinery, and the nature of its parts, in the class room; the materials of construction in the chemical and physical laboratories; the thermodynamics of gases in the class room and engine room; but he performs work in commercial shops, foundry and power plant, on commercial machines, working factory hours alongside skilled mechanics. He not only hears lectures on the theory of business and shop management, but he handles and becomes familiar with such things as cash books, ledgers, time cards, pay rolls, shop reports, shipping receipts, balance sheets, and contracts. Different systems of time cards routing cards and cost systems can be tried out in the shops under real conditions, and the student becomes aware of every element of cost and of its relative importance in the price of an article of manufacture.

Men who have a natural ability for managing find after taking this course at Worcester that it has given them a tremendous start; that it has bridged for them the gap between their regular college course in "raw" engineering science, on the one side, and their practical usefulness, on the other. Their shop training work has been as near actual experience as it is possible for them to get.

It is commonly believed that such a mixture of theory and practice as this does not lend itself to courses of study in a professional school. The key, however, to success is the possession of adequate commercial shops within the direct control of the institution; and although the Department of Mechanical Engineering at Worcester provides all of the foregoing practical instruction in the regular course leading to the degree of B.S. in that department, it nevertheless does not fail to give as many hours devoted to pure physics, pure mathematics and those studies ordinarily called the humanities as are required by any other engineering school in this country; so that nothing in the way of high scientific attainment is sacrificed in order to secure time for these other no less important practical studies.

If the society's well known interest in the problem of modern scientific industrial education shall insure the presence of a large representation in June, it will add greatly to the success of the occasion.

G. I. Rockwood, Chairman. } *Entertainment*
R. Sanford Riley } *Committee,*
Victor E. Edwards } *Am. Soc. M. E.*

SAN FRANCISCO MEETING

A meeting of the Society is to be held in San Francisco on September 16 and 17, in connection with the Pan-American Exposition which had its formal opening on February 15.

For the benefit of those who will attend a special train schedule will be arranged over the Southern Pacific. It is planned to pick up at New Orleans those members who will start from the Middle West or South and other points further West than New York.

According to the schedule as at present arranged, the

party will leave New York either Thursday evening, September 9, or Friday evening, September 10, and will stop at Niagara Falls, the Grand Canyon and possibly Colorado Springs. The Hotel Clift has been selected as the headquarters of the Society during the meeting.

An International Engineering Congress will be held in San Francisco from September 20 to 25.

ADDITIONAL GREETINGS

The president of The American Society of Civil Engineers, Prof. Chas. D. Marx, lives in California and thus was unable to speak for his society at the meeting for establishing the Engineering Foundation. He had asked Mr. Clemens Herschel to represent the Society, who by misadventure was also prevented from attending, but who has sent in what, if present, he had intended to say. Mr. Herschel writes:

I believe I convey to you the unanimous desire of our members, when, in their behalf, I am wishing a great future for the Engineering Foundation and am bringing a great measure of thanks to its founder.

The Society appreciates the honor of being allowed to take a part in these exercises, and in the future administration of the Foundation. We here can say to the generous donor, paraphrasing what Latimer said to Ridley:

"Be of good comfort, Master Swasey, we shall this day light such a candle, by God's grace, as I trust shall never be put out."

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i. e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before April 10, 1915.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ALBIN, LELAND D., with Ingersoll-Rand Co., New York

ALCOCK, GEORGE W., Engrg. Dept., American Locomotive Co., New York

BARTLETT, D. DANA, Cons. Engr., Sloan, Huddle, Feustel & Freeman, Madison, Wis.

BARR, CLARENCE D., Ch. Engr., American Cast Iron Pipe Co., Birmingham, Ala.

BENNETT, ARTHUR N., Supt. Mfg. Dept., Safety Car Htg. & Ltg. Co., Jersey City, N. J.

BERGGREEN, PAUL H., Librarian, Sibley College, Cornell University, Ithaca, N. Y.

BLAIR, GEORGE JR., with McClave-Brooks Co., Scranton, Pa.

BRASSINGTON, JOHN W., Engr. Drawing Room, The Pusey & Jones Co., Wilmington, Del.

BROWN, CECIL W., Indus. Pwr. Specialist, Stone & Webster Mgt. Assn., Boston, Mass.

BROWNING, EARL H., first Vice-Pres., The Browning Co., Cleveland, Ohio

BUTLER, THOMAS M., Genl. Foreman, Bauroth Mch. & Tool Co., and Toledo Barrel Co., Toledo, Ohio

CHENEY, FRANK, JR., Pres., Cheney Bros., South Manchester, Conn.

COLLINS, HUBERT E., Cons. Engr., Remington Typewriter Co., Utica, N. Y.

COUSINS, GEORGE T., Mech. Engr. Rock Drill Dept., Ingersoll-Rand Co., New York

CZAJKOWSKI, ALEXANDER, Ch. Draftsman, Byron Jackson Iron Wks., West Berkeley, Cal.

DAVIDSON, JOHN C., Ch. Engr., The S. S. White Dental Mfg. Co., Prince Bay, N. Y.

DAVIS, CHARLES B., Engr., C. B. Davis Engrg. Co., Birmingham, Ala.

DICKINSON, ARTHUR R., Textile Rep., Lockwood, Greene & Co., Atlanta, Ga.

DIESCHER, SAMUEL E., Cons., Mech. and Civ. Engr., Pittsburgh, Pa.

DODGE, HORACE E., Vice-Pres. and Genl. Mgr., Dodge Bros., Detroit, Mich.

ELDER, EDWARD H., Cons. Engr., Springfield, Mass.

ELLIOTT, WILLIAM, JR., Boiler Manufacturer, Leslie & Elliott Co., Paterson, N. J.

FISHER, FRANCES P., Asst. Genl. Mgr., Wichita Natural Gas Co., The Quapaw Gas Co., Arkansas Valley Gas Co., etc., Bartlesville, Okla.

FORBUSH, FRANKLIN L., State Inspr. of Boilers and Examiner of Engrs., Commonwealth of Mass., North Adams, Mass.

GREEN, WALTER H., Ch. Engr., International Filter Co., Chicago, Ill.

HALBFASS, ARNOLD J., Asst. Engr., Gasoline Div., General Vehicle Co. Inc., Long Island City, N. Y.

HALYBURTON, FREDERICK J., Ch. Estimator, Taylor Wharton Iron & Steel Co., High Bridge, N. J.

HORNER, HENRY O., with the Horner Double-Acting Eng. Co., New York.

HUDSON, DARWIN S., Supvrg. Field Engr., Constr. Dept., Consolidated Gas Co. of N. Y., New York

HUMPHREY, ARTHUR L., Vice-Pres. and Genl. Mgr., Westinghouse Air Brake Co., Wilmerding, Pa.

JONES, LEWIS, Assoc. Editor, "Power," New York

KENNICOTT, CASS L., Vice-Pres. and Genl. Mgr., The Kennicott Co., Chicago Heights, Ill.

KIMBALL, DWIGHT D., Cons. Engr. and Treas., Richard D. Kimball Co., New York

KNEN, WILLIAM E., Ch. Draftsman, Bureau of Water, Dept. of Public Wks., Philadelphia, Pa.

KNIGHT, IRA D., Engr. Drive Chain Dept., Link-Belt Co., Chicago, Ill.

KNIGHT, WILLIAM A., Assoc. Prof. Mch. Shop Practice, Ohio State Univ., Columbus, Ohio

KOINER, C. WELLINGTON, Genl. Mgr., Elec. and Mech. Engr., Pasadena Municipal Lt. & Pwr. Plant, Pasadena, Cal.

KREHER, ERNEST, Pres. Mech. Engr. and Genl. Mgr., Tampa Foundry & Mch. Co., Tampa, Fla.

LAW, OCTAVIUS A., Mech. Engr., The Midvale Steel Co., Philadelphia, Pa.

LAWRENCE, NORMAN S., Ch. Estimating Engr., Whiting Foundry Equipment Co., Harvey, Ill.

LESLIE, DAVID, Boiler Manufacturer, Leslie & Elliott Co., Paterson, N. J.

LEWY, DANIEL, Western Mgr., Standard Plunger Elevator Co., Chicago, Ill.

LOVELL, RALPH L., Cons. Engr. and Patent Expert, Quincy, Mass.

LYKE, HENRY W., Genl. Supt., Ames Iron Wks., Oswego, N. Y.

MCCABE, JOHN C., Ch. Boiler Inspr., City of Detroit, Mich.

MCCANN, FRANK G., Ch. of Heating and Ventilating Div., Board of Education, New York

MCGRAIL, FRANCIS J., Foundry Supt., Struthers-Wells Co., Warren, Pa.

MCNAMARA, THOMAS, Ch. Engr. and Master Mech., National Silk Dyeing Co., Paterson, N. J.

MACKINNON, Ch. Inspr., Compensation Inspection Rating Board, New York

MAKEPEACE, CHARLES R., Mill Architect and Engr., Providence, R. I.

MANTIUS, OTTO, Ch. Engr., and Vice-Pres., Zaremba Co., Buffalo, N. Y.

OLSON, LOUIS W., Supt. and Wks. Mgr., The Ohio Brass Co., Mansfield, Ohio

PARK, CHARLES F., Prof. of Mechanism, Massachusetts Inst. of Technology, Boston, Mass.

PARKER, THOMAS R., Supt. Eagle Wks., Standard Oil Co., Claremont, Jersey City, N. J.

PEACOCK, EDGAR A., Wks. Mgr., Fdy. and Mch. Shops, Atlantic, Gulf & Pacific Co., Manila, P. I.

PEASE, FRANCIS G., Astronomer, Mt. Wilson Solar Observatory, Pasadena, Cal.

PEASE, OSCAR D. A., Test Dept., Pennsylvania R. R. Co., Altoona, Pa.

PINKNEY, DAVID H., Ch. Draftsman, Pipe and Tube Mill Dept., The National Tube Co., Lorain, Ohio

POWER, WALTER J., Vice-Pres. and Efficiency Engr., The Emerson Co., New York

RAUSCH, JULIUS W., Mgr., Fly-Wheel, Sprinkler Leakage and Water Damage Depts., Maryland Casualty Co., Baltimore, Md.

REED, VAN A., JR., Treas., Federal Engrg. Co., Pittsburgh, Pa.

REYNOLDS, HERMAN W., Prof. of Mech. Engrg., and Cons. Engr., Univ. of the Philippines, Manila, P. I.

RICE, CYRUS W., Steam and Genl. Testing Engr., Atlantic Refining Co., Philadelphia, Pa.

SAALFRANK, JOHN M., Mech. Engr., DeLong Hook & Eye Co., Philadelphia, Pa.

SCHAUP, CHARLES E., Cons. Engr. and Ch. Engr., Lebanon Valley Cons. Water Supply Co., Harrisburg, Pa.

SCHIELDGE, GEORGE K., Supt., Taylor & Fenn Co., Hartford, Conn.

SCHNEIDER, RUDOLPH, Designing Engr., Busch-Sulzer Bros.-Diesel Eng. Co., St. Louis, Mo.

SHEPPARD, AULEY B., Dept. Head and Ch. Engr. Linoleum Dept., Armstrong Cork Co., Lancaster, Pa.

SIMPSON, ROSWELL H., Ch. Draftsman, Edison Laboratory, West Orange, N. J.

SLADER, WALTER, Mech. Engr., with John A. Stevens, Cons. Engr., Lowell, Mass.

SLOAN, ROBERT F., Genl. Mgr., Charlevoix Rock Product Co., Charlevoix, Mich.

STANNARD, JAMES M., Mgr., Chicago Office, American Steam Pump Co., Pres. and Treas., Stannard Pwr. Equipment Co., Chicago, Ill.

STEVENSON, WILLIAM H., Secy., Power Plant Specialty Co., Chicago, Ill.

STOLBRAND, VASA E., Headmaster, Shattuck School, Inc., Faribault, Minn.

STONE, DWIGHT G., Secy., Sprinkler Leakage & Fly Wheel Depts., The Aetna Accident & Liability Co., Hartford, Conn.

STORMS, FRANK F., Pres., Page-Storms Drop Forge Co., Chicopee, Mass.

STUBBS, FREDERICK W., Mech. Engr., Chicago Great Western R. R. Co., Oelwein, Ia.

THOMPSON, JOHN R., Senior Mech. Engr., Interstate Commerce Commission, Chicago, Ill.

VATER, FRANK F., Pres., Power Plant Specialty Co., Chicago, Ill.

VERHEY, HUBERT C., Ch. Designing Engr., Marine Eng. Dept., Busch-Sulzer Bros.—Diesel Engine Co., St. Louis, Mo.

WALDRON, J. LAURENCE, Inspr., Testing Bureau, Transit Development Co., Brooklyn, N. Y.

WASHBURN, JOHN E., Mech., Engr. and Asst. Master Mech., National Carbon Co., Cleveland, Ohio.

WHITE, D'ORSAY MCC., Engr., The Cadillac Motor Car Co., Detroit, Mich.

WILDE, JOHN R., Ch. Engr. of Pwr. Plants, The Edison Ill. Co., Detroit, Mich.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ARNSTEIN, LEONARD A., Supt., Imperial Metal Mfg. Co., Long Island City, N. Y.

AVERY, A. ORDELL, Head of Sect., Layout Dept., Western Elec. Co., Chicago, Ill.

BEAMAN, PHINEAS A., Mech. Engr., Willett, Sears & Co., Boston, Mass.

BIDDISON, PASCAL MCD., Constr. Engr., Ohio Fuel Supply Co., Columbus, Ohio

BOWLES, WILLIAM A., JR., Engr., Constr. Dept., Appalachian Pwr. Co., Bluefield, W. Va.

BURROWS, GROVER C., Civil Engr., C. W. Blakeslee & Sons, North Branford, Conn.

CAMPBELL, JAMES A., Mech. Supt., Renfrew Mfg. Co., Adams, Mass.

CLUCAS, GEORGE W., Engr., Chicago Office, American Steam Pump Co., Secy., Stannard Pwr. Equipment Co., Chicago, Ill.

EGBERT, HARRY D., Asst. Engr., The Research Corp., New York

ELMER, NIXON W., Engr., The Lamson Co., Boston, Mass.

GIBBS, GEORGE W., Jr., Manufacturer, Gibbs Gas Eng. Co., Jacksonville, Fla.

HAAS, HARRY A., Cartridge Designing, Winchester Repeating Arms Co., New Haven, Conn.

HOBBS, GEORGE W., Instr. in Engrg., Univ. of Wisconsin, Madison, Wis.

HOLCK, HARRY C., Draftsman, Public Service Elec. Co., Newark, N. J.

JACK, RICHARD D., Engr., Clinton H. Scovell & Co., Boston, Mass.

KLOCKE, JOSEPH F., Designer, E. W. Bliss Co., Brooklyn, N. Y.

WHITE, KENNETH, Engr., By-Products Coke Corp., Chicago, Ill.

SUMMARY

New applications..... 101

IRON AND STEEL SESSION

SIMULTANEOUS with the afternoon session of the Public Service meeting, a professional session was held devoted to iron and steel topics. Three papers were presented followed by a topical discussion on alloy steels and kindred subjects. The meeting was unusually successful as it was well attended and continued for over three hours. The papers presented were as follows: Factors in Hardening Tool Steel, John A. Mathews and Howard J. Stagg, Jr. (Contributed by the Sub-Committee on Iron and Steel); Standardization of Chilled Iron Crane Wheels, F. K. Vial (Contributed by the Sub-Committee on Hoisting and Conveying); and The Mechanical Elimination of Seams in Steel Products, Notably Steel Rails, R. W. Hunt.

FACTORS IN HARDENING TOOL STEEL

BY JOHN A. MATHEWS, SYRACUSE, N. Y.

Member of the Society

and

HOWARD J. STAGG, JR.,[1] SYRACUSE, N. Y.

Non-Member

The paper is devoted primarily to the practical side of the art of hardening and tempering tool steel, carbon steels being considered in the first place (0.60 to 1.50 per cent carbon).

The authors explain at some length the structural variations of steels as a function of carbon content and temperature, as well as the influence of the critical ranges of temperature on the properties of steel, with particular attention to volume changes (variation of expansion with temperature). In case of overheating, the first cooled portion is hardened first, forming an unyielding shell, and a strain is set up by the slower cooling interior which may lead to cracks and ruptures.

Time of Heating. The time of heating is of extreme importance for the strength of the piece: if the heating is too fast, the temperature through the piece will not be uniform, while long heating leads to the formation of abnormal size of grain and weakness of the metal. A very bad practice is quick heating in a furnace which is considerably hotter than the correct hardening temperature. The difficulty is that the thin parts, corners, and edges are liable to attain an overheated temperature before the larger portions of the piece attain the correct hardening temperature, and this overheating of the thin parts produces large grain size, abnormal expansion and tends to produce cracks.

Speed of Quenching. The metal must be cooled quickly, so as to obtain martensite, which is the correct constituent of hardened steel. The authors illustrate the influence of quenching by two examples which however are not tool steels, and after mentioning, according to Benedicks,[2] the conditions which a liquid must have to exhibit a good quenching power, proceed to report their own tests of various quenching media which included pure water, brine solutions, and various oils. The results obtained are expressed in the form of curves.

In attacking the problem, the following method was adopted: A test piece of the dimensions shown in Fig. 1 was machined from a solid bar, and a hole drilled through the neck to within an equal distance from each side and bottom of the test piece. Into this hole a calibrated, platinum-rhodium couple was inserted and the leads connected to a calibrated galvanometer. The test piece was then immersed in a lead pot, also containing a thermo-couple to the point *A*, and the lead pot was maintained at a temperature of 1200 deg. fahr. When the couple inside the test piece was at 1200 deg. fahr., and the couple in the lead pot read 1200 deg. fahr., the test piece was removed and quenched to the point *B* in 25 gal. of the quenching medium under consideration. At the start the quenching medium was maintained at room temperature. The time in seconds that it took the test piece to fall from a temperature of 1200 deg. fahr., to a temperature of 700 deg. fahr., was noted by the aid of a stop-watch. It is clear that immersing the test piece in the quenching medium raised the temperature of the medium. The test piece was then replaced in the lead, heated to 1200 deg. fahr., quenched into the medium at this higher temperature and the time again taken with the stop-watch. These operations were continued until the quenching media, in the case of oils, had attained a temperature of about 250 deg. fahr. The results obtained, time in seconds, for a fall from 1200 deg. fahr. to 700 deg. fahr., were plotted against the temperature of the quenching medium and a series of curves as shown in Figs. 2 to 8 inclusive were obtained.

A consideration of the results is interesting. Pure water (Fig. 2) has a fairly constant quenching rate up to a temperature of 100 deg. fahr., where it begins to fall off. At 125 deg. fahr., the slope is very marked. Brine solutions (Fig. 2) have both a quicker rate of cooling and are more effective at higher temperatures than water. The curve does not begin to fall off seri-

[1] Halcomb Steel Co.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to non-members.

[2] Journal of the Iron and Steel Institute, 1908, II., p. 212.

ously until a temperature in the neighborhood of 150 deg. fahr. is reached. Where water at 70 deg. fahr., cooled the test piece in 60 sec., the brine solutions cooled it in 55 sec.

Oils are slower in their quenching powers than water or brine solutions, but the majority of them have a much more constant rate of cooling at higher temperatures.

The curves shown in Figs. 7 and 8 are for thick viscous oils somewhat similar to cylinder oils. These curves are particularly interesting in that they have

4 in. long were made from the same ingot in sizes increasing $\frac{1}{8}$ in. in breadth and thickness. The smallest was $\frac{3}{8}$ in. square and the largest $3\frac{1}{4}$ in. square. Three ingots of different analysis were shown and a series of test pieces made from each. The test pieces were heated in a semi-muffle furnace to a constant temperature quenched, and the Brinell hardness test made. Each series was then drawn to 600 deg. fahr. in a salt bath and Brinell tests again taken and then reheated to 1200 deg. fahr. in a salt bath and Brinell hardness tests again run.

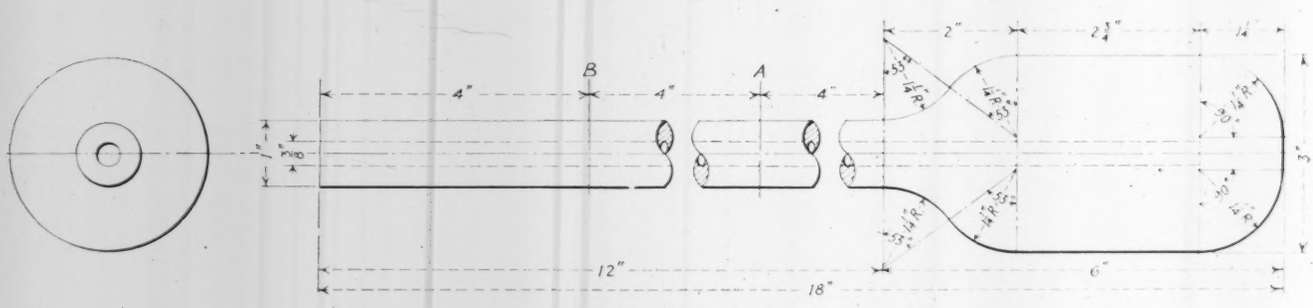


FIG. 1 TEST PIECE USED IN QUENCHING TESTS

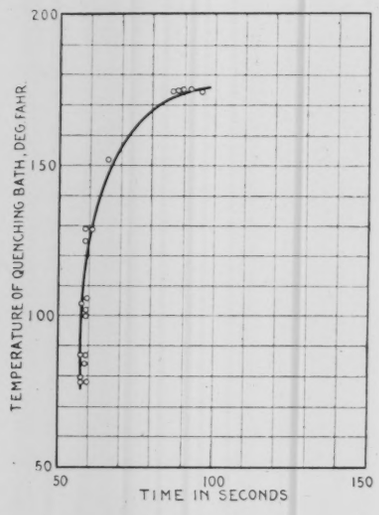


FIG. 2 QUENCHING POWER OF SYRACUSE CITY WATER

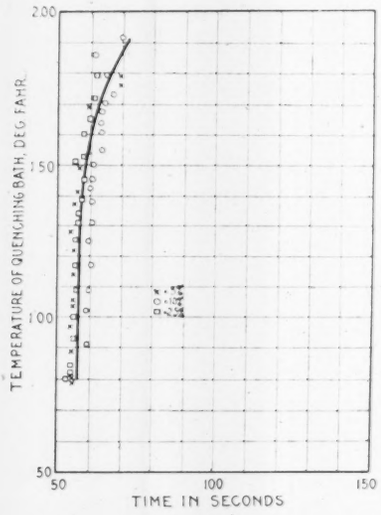


FIG. 3 QUENCHING POWER OF BRINE SOLUTIONS

slower quenching abilities at low temperatures than at higher temperatures.

A comparison of curves in Figs. 4 and 5 shows the variation in quenching power of the same oil due to continued service. The differences in quenching rates may well account for different results from the same steel in different shops, or in the same shop due to change of oil used.

Hardness as Affected by Mass. Figs. 9 to 12 inclusive show results from quenching different masses of the same material under like conditions. Test pieces

It will be noted that the smaller the sample the greater the figure of hardness, indicating that the smaller sections are cooled with greater rapidity than the larger. The same agencies are at work in tool steel. The larger the mass the smaller the depth of hardness when quenched under similar conditions. In order to produce the same amount of hardness in a small and large section it is necessary to heat the larger section hotter than the smaller. A commercial application of this phenomenon will perhaps be interesting. The authors were recently confronted with the

problem of finding out the correct temperature for hardening tools made from the same steel in sizes varying from $\frac{1}{16}$ in. diameter to $\frac{3}{4}$ in. diameter. The temperature-size curve shown was finally adopted (Fig. 13). In other words, a $\frac{3}{16}$ in. round will harden at 1395 deg. fahr., while a $\frac{3}{4}$ in. round bar should be heated to 1450 deg. fahr.—a difference of 55 deg. fahr.

Time and Degree of Drawing Temper. After the hardening operation has been safely performed, the next important step is that of drawing the temper. This operation is necessary for two important reasons:

a The relieving of abnormal strains set up due to the quick contraction or expansion.

constant temperature for five minutes, fifteen minutes, etc.

Elastic Limit	Maximum Strength	Elongation	Reduction	Brinell	Remarks
228,750	260,137	2.5	....	425	1550-oil-800 deg. fahr. 8 min.
201,125	214,562	11.6	45.4	390	1550-oil-800 deg. fahr. 20 min.
175,000	183,187	12	49.35	340	1550-oil-800 deg. fahr. 40 min.

A study of the table shows that time at the drawing temperature has a marked effect. The act of breaking down the martensite is progressive and not sharply defined. Both time and temperature have their effects.

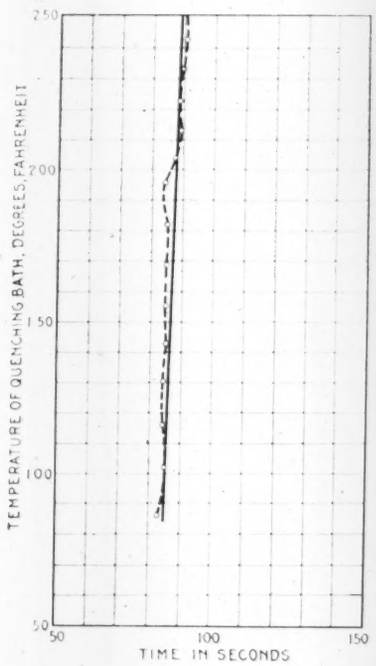


FIG. 4 QUENCHING POWER OF NO. 2 LARD OIL

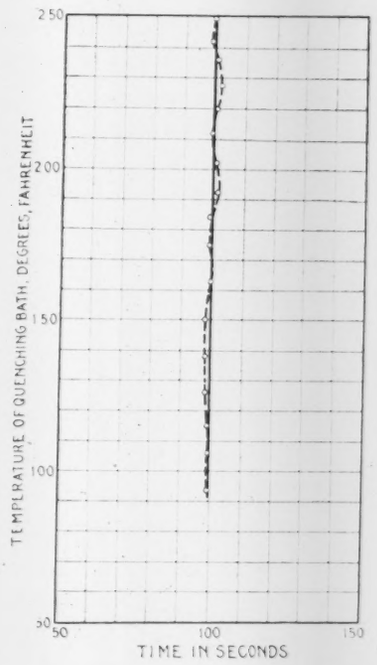


FIG. 5 QUENCHING POWER OF PRIME LARD OIL IN USE TWO YEARS

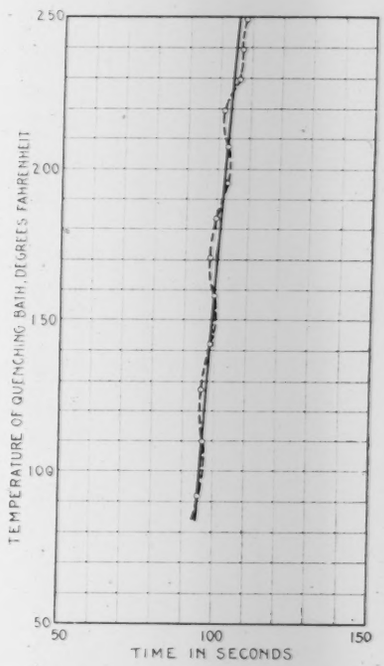


FIG. 6 QUENCHING POWER OF RAW LINSEED OIL

b The breaking down of the extremely hard and brittle structure of the quenched steel.

The drawing of the temper begins to break down the true martensitic structure and as the temperature increases there are formed intermediate micro-structures between martensite and pearlite, first troostite, then sorbite, and finally pearlite.

Professor Heyn has published some valuable results on the decrease of hardness on tempering. The results are expressed in per cent of the original hardness.

100 deg. cent.	2.5 per cent.	400 deg. cent.	70.0 per cent.
200 deg. cent.	14.0 per cent.	500 deg. cent.	87.5 per cent.
300 deg. cent.	41.0 per cent.	600 deg. cent.	97.5 per cent.

Regarding the effect of time on drawing the temper, standard $\frac{1}{2}$ in. round A.S.T.M. test pieces were quenched from constant temperature into the same medium, and the temper drawn in same salt bath at

The greater the initial hardness of the piece, the more marked is the effect of drawing the temper. By referring to Figs. 9 to 12 inclusive the actual values in Brinell hardness are shown. The piece of 0.25 carbon nickel, $\frac{5}{8}$ in. sq., quenched in oil, shows a Brinell of 360; drawn to 1200, a Brinell of 223. The per cent decrease in hardness is 61. The piece of $3\frac{1}{4}$ in. sq., quenched shows a Brinell of 208; drawn to 1200 deg. fahr., Brinell 183, showing a decrease in hardness of only 13 per cent.

Many years ago, one of the authors made several hundred hardening experiments and several thousand measurements to study the change of shape. The materials used were cylinders of steel and taps. Crucible steel alone was examined and the following variables were considered: (*a*) the effect of original form or

diameter upon the diameter after hardening; (*b*) the influence of carbon on change of form; (*c*) the influence of initial temperatures at quenching; (*d*) the influence of length of time of heating; (*e*) the influence of repeated hardenings, and (*f*) the effect of annealing previously hardened steels, upon change of shape in rehardening. Obviously when plain cylinders of steel are considered, there are four possible changes of shape, expansion in length and diameter, contraction in length and diameter, expansion in length and contraction in diameter, and contraction in length with expansion in diameter.

Under the influence of the variable conditions mentioned above, all four changes were actually produced.

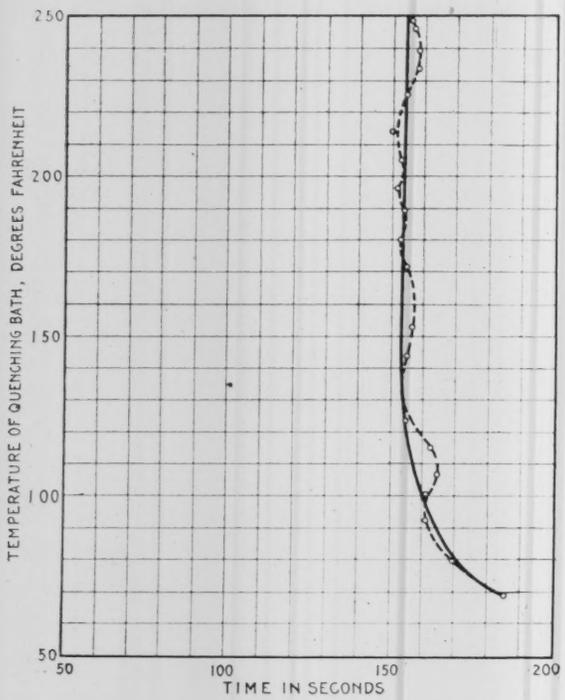


FIG. 7 QUENCHING POWER OF NO. 1 DARK TEMPERING OIL

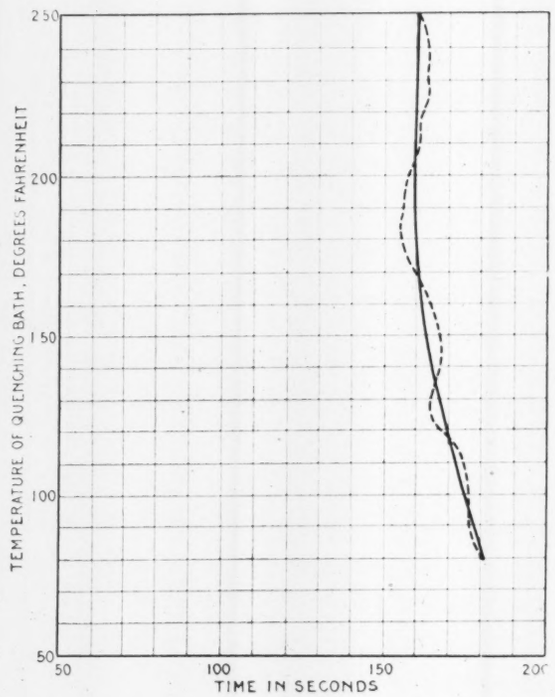


FIG. 8 QUENCHING POWER OF SPECIAL "C" OIL

Steel was also found which expanded in length on first hardening and contracted indefinitely thereafter on repeated hardenings. Another steel expanded in length on two hardenings and contracted on the next two. In a variable carbon series of steels from 0.50 to 1.33 per cent carbon, the magnitude of the change in length after four hardenings, increased as the carbon increased. For the same series it was noted that the volume changes were greater when hardening annealed rather than unannealed bars. The increase in length is greater the higher the hardening heat for all carbons.

These tests emphasize the fact that variable conditions produce variable results. It is of vital importance that steel be furnished uniform, chemically as well as physically, and it is equally important that the user employ every possible refinement in the handling of his product. It is only under varying conditions of heat, size, time, composition, etc., that the results vary. Different steels will not behave alike in all cases, but it is a simple matter to determine under any given set of conditions how a particular steel will behave. Other things being equal, therefore, the original composition, grain size, condition of annealing and the method of manufacture affect the resulting changes in form after hardening. Above the decalescence point, the coefficient of dilatation increases proportionately with the carbon and for all carbon percentages the rate of dilatation increases with the temperature. Resulting changes of form are conditioned by the original proportions of the piece quenched, by its chemical composition, by the temperature from which it is quenched, and within certain limits by the time of heating. Hardness, brittleness, change of form and liability to crack, generally speaking, increase with the carbon content and the temperature and time of heating. Nevertheless, constant conditions give constant results.

Constant conditions are not always attainable. The maker of steel cannot control conditions in his customer's shop and the customer cannot control conditions in the steel plant, and the human element must be considered in both. The properties described are inherent properties of carbon steel, and because of them many a dispute has arisen over tools lost in hardening. The placing of the exact responsibility is very difficult.

Furnaces and Methods of Heating. Much has been

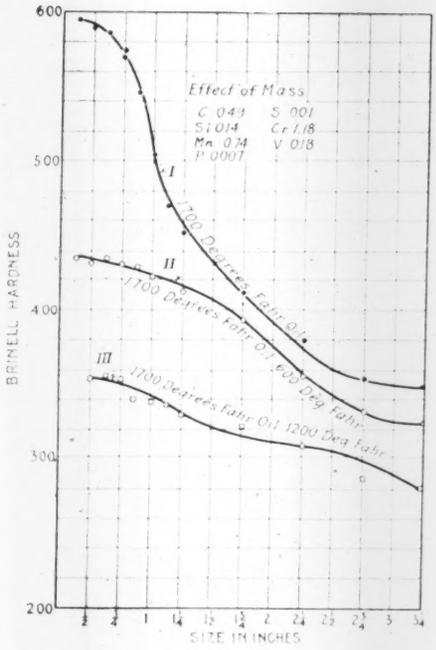


FIG. 9

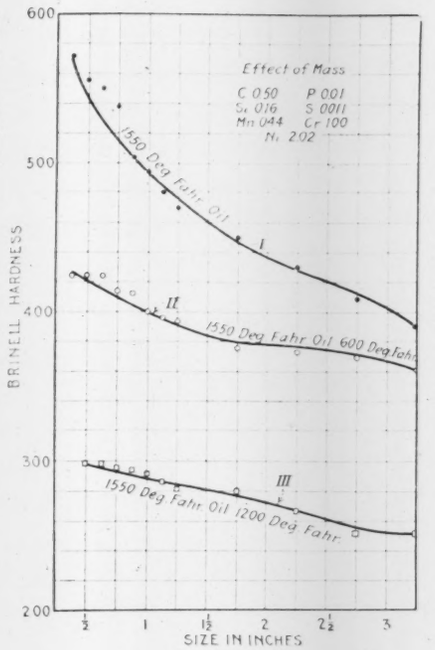


FIG. 10

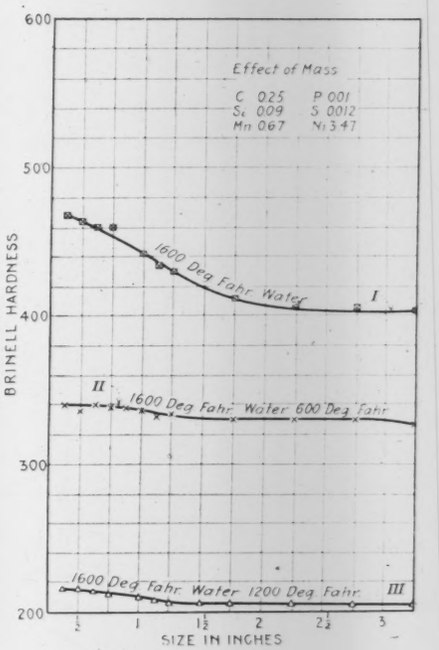


FIG. 11

BRINNELL HARDNESS OF TEST PIECES AFTER QUENCHING TO SHOW EFFECT OF MASS

said regarding the superiority of gas furnaces over oil furnaces and vice versa. The fuel used is immaterial for good practice so long as the following points are taken care of:

a The furnace and hearth should be of sufficient size so as not to be affected materially in temperature by the introduction of the parts to be hardened.

b The furnace should heat at a uniform rate.

c The furnace should be of uniform temperature over its entire hearth.

d The furnace should be run under neutral, or reducing conditions. A good rough test for this is the introduction of a piece of wood or paper upon the hearth. If the paper, or wood, burn, the atmosphere is oxidizing. If they char, reducing or neutral.

e The temperature control must be at all times exact and it must be possible of exact duplication on repetition work.

A blacksmith's fire is satisfactory under good handling, but for constant work it is too exacting on the operator and requires too many manipulations to secure uniform and continuous results. To expect uni-

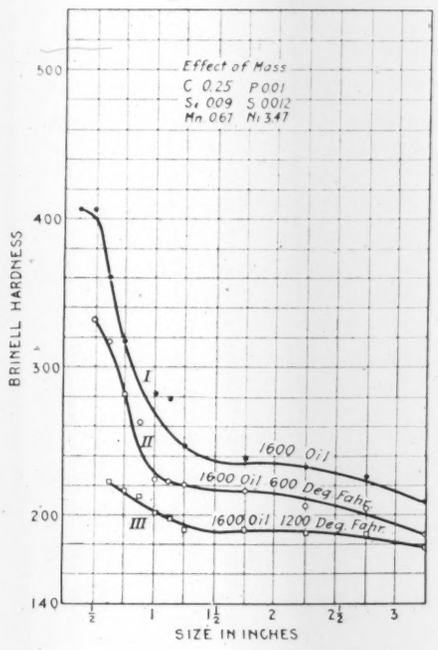


FIG. 12 BRINNELL HARDNESS TO SHOW EFFECT OF MASS

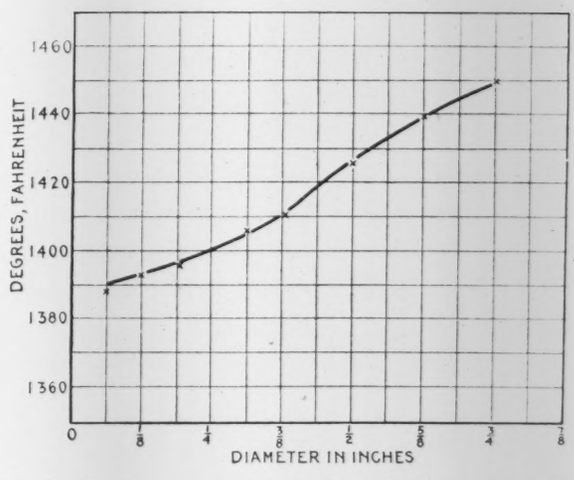


FIG. 13 TEMPERATURE—SIZE CURVE FOR HARDENING TOOLS

formly good and consistent results from a hardener not provided with adequate or suitable equipment is unreasonable. When the question of good equipment in the way of furnace, quenching arrangements and media, pyrometers, etc., has been satisfactorily taken care of, the hardener still has plenty of variables to contend with which are beyond his control.

DISCUSSION

HENRY M. HOWE[1] in a written discussion particularly endorsed the use by the authors of their ingenious method of determining the rate of cooling of different liquids, a method which can be applied without the use of sensitive instruments, and is superior to that of Benedicks.

With reference to carbon, it should be understood that the pearlite and the excess of ferrite and cementite referred to are not always recognizable under the microscope. Under certain conditions they are apt to be all mixed in such a fine emulsion (called "sorbite") that they cannot be recognized individually.

Referring to the position of the critical temperature in carbon steels, it should be understood that the influence of manganese and nickel in lowering the transformation range is primarily through their increasing the hysteresis. When the decalescence points are determined, it is found that they have not been very greatly lowered, while the observed lowering of the recalescence point represents chiefly hysteresis.

Further, the writer indicated several additional authorities, especially the work of Benedicks, and approved of the results given in Table 1 on the penetration of hardness. In reality, the hardness of the corners and edges exceeds that of the interior of the piece even in a greater degree than these numbers would indicate, for the reason that when the Brinell ball is pressed into the specimen near its edge, and more particularly near its corner, its indentation is abnormally great because of the proximity to the side of the piece.

Figs. 9 to 12 indicate that our previous belief as to the completeness of annealing at 600 deg. cent. was incorrect, thus showing that what Goerens found for very low carbon steel, does not hold for hardening caused by rapid cooling. Similarly, the results in the table which show that at 430 deg. cent. the tempering was very far from reaching the maximum for that temperature even after a sojourn of 20 minutes, disagree with the earlier and very precise determinations of Barus and Strouhal who found that the tempering at these temperatures reached its maximum very quickly. One is at first tempted to refer the softening observed after the 20 minutes and the 40 minutes exposure of the authors to opportunity for coalescence of the sorbite, but it seemed to the writer that the loss of elastic limit and hardness is too great to be accounted for in this way.

J. J. RALPH in a written discussion called attention to the experiments on cylinders which expanded or contracted in length or cross-sectional area or both. The results coincide with some experiences of the writer with hypo-eutectoid steels of about 0.45 per cent carbon.

Finished pieces about 2 in. in diameter with 0.001 in. tolerance showed differences as much as 0.002 in. above high to 0.002 in. below low limit after hardening. It being quantity production, this was obviously very expensive, requiring either the scrapping of the piece or costly finishing of extremely hard surfaces. Closer observation showed it to be the result of variations in quenching temperatures. This pointed to a temperature at which the steel could be hardened and at which it would neither shrink nor expand. Instructions were given to the machine shop to hold the piece as closely as possible to the high limit and suitable care being given, 90 per cent was finally going direct through inspection to assembly. Further investigation showed that the facilities for measuring temperature were not delicate enough to allow the fine control necessary. Nor could it be sure that the steel was running evenly enough chemically (it was a low price openhearth low carbon, low phosphorus and sulphur) to allow the fixing of a definite range. Quenching conditions, both as to composition of the quenching material and its temperature were far from ideal, thus giving three variables which were unknown.

A case has come to light where this ideal was reached. The steel was about 0.6 per cent carbon. It involved control of temperature to within a total range of less than 5 deg. fahr. considerably less than the instrument error of the best of indicating pyrometers and was only made possible by the use of a bath furnace and the resistance thermometer.

Skilled practical men, knowing the steel they are working with, are willing to guarantee almost a finished hardened piece exact to size and shape. A comparison of results obtained by several skilled smiths will show a surprising difference, probably owing to different kinds of steel they have been accustomed to handling. It must not be overlooked that the usual hardening room and machine shop conception of "exact" is far from perfect.

Investigation of hardening defects is not usually as thorough as it should be. It is hampered by ignorance of past conditions and the effect of previous operations, lack of knowledge of the steel used, human elements of feeling as to the money involved, responsibility, and a feeling that steel is steel and does what it does. Seldom is an attempt made to reproduce the defect thus proving conclusively what the cause was.

In his own work on long relatively slender pieces, the writer found most of his trouble in distortion due to bending in heating. Steel when hot seems to bend under the application of a steady, even, though slight load, the weight of the part being hardened often being sufficient to cause very noticeable distortion. Another case is initial condition of strain, either due to forging, rolling, machining or accident. When the bar is heated, the strains are relieved and there is a bending or twisting of the piece in readjustment. These are particularly annoying in fine work and in one case the substitution of square for round stock eliminated this trouble in a round machined piece.

If a practical way could be found to hold hardened pieces to size and shape, it would be possible to do all of the machining with the piece soft. A very material shop saving would be obtained and it would also allow the use of parts with physical characteristics as we would like to have them instead of makeshifts in many places. The problem has been simplified within the past year by the introduction of the potentiometer type pyrometer with a possible commercial accuracy in skilled hands of about one deg. fahr.

[1] Columbia University, New York.

O. R. CARY[1] stated that he had occasion to produce a number of die blocks of the average size of 5 by 3 by 1 in. These were treated in an electric resistance furnace. It was found that if a certain size was heated in 44 minutes to the proper point, as indicated by the passage of that piece through the transformation point by about 20 or 25 deg., a die was obtained which required no further chemical treatment. A cut of less than a thousandth of an inch cleared it perfectly. If it was heated in 38 instead of 44 minutes, a cut of at least four-thousandths was required to clear the surface, with similar changes in shape. This period of 44 minutes happens to be the constant for this particular furnace; for some other furnace it undoubtedly would be different. But it has been proved that if you vary the point of heating ordinary carbon commercial steel by as much as 5 per cent, you have varied the shape of your piece perceptibly.

A great many of the troubles in the treatment of such masses of metal have been laid either to steel or to pyrometers.

BRADLEY STOUGHTON expressed his appreciation of the paper and said that if it should result in reducing to a science some of the rules of thumb with which steel tempering men are accustomed to work, it would be a great help. He was particularly interested in the experiments outlined on the effect of mass. Those who have tempered large pieces of steel have noticed one difficulty which occurs occasionally, particularly in dies. If the die is large so that the mass of the metal is considerable there is liable to be a soft zone of metal immediately under a very hard exterior so that the die will frequently drop, as they call it. This has undoubtly been explained by the author and by Professor Howe. The exterior of the metal cools and shrinks in the interior; then the interior in its cooling shrinks away from the hard exterior which will naturally produce a zone of soft metal. He hoped that the author and his associates might throw some light on a better quenching medium for steel of large mass.

JOHN A. BRASHEAR by way of illustration of the extreme refinement required in the treatment of steel in order to secure homogeneous material, said that 10 or 15 years ago he was asked to make a rotating mirror to determine not only the velocity of light, or redetermine it, but for the purpose of determining the variation of the speed of the various wave-lengths, if possible. The mirror was to rotate some 30,000 revolutions per minute and its four sides had to be located so that they were absolutely equi-angular with the surfaces. The image of a star thrown on the surface of one of the sides had to go about three miles away and then come back without being distorted, which illustrates the extreme accuracy required. Not only was great difficulty experienced in the mechanical problems involved, but also in getting homogeneous surfaces of a standard quality of hardness so that each surface would polish the same. If one spot on the surface was a tiny little bit different from any other spot, the surface would be a little low where it was softer and a little high where it was harder. The work, however, was finally accomplished and the mirror has been used for making a number of light determinations.

THE AUTHORS answered numerous inquiries during the discussion regarding various points in the paper upon which further information was desired. Mr. Stagg in response to the request of the chairman for a topical discussion upon alloy steels supplementing the information given in the paper, showed a number of interesting lantern slides of microphotographs of alloy steel and explained their characteristics.

[1] Leeds and Northrup Company, Philadelphia.

STANDARDIZATION OF CHILLED IRON CRANE WHEELS

BY F. K. VIAL,[1] CHICAGO, ILL.

Non-Member

This paper presents the results of an extended investigation of the whole subject of chilled iron wheels for cranes. Because of the great quantity of summarized and tabulated data which the paper contains, it is not possible to prepare a comprehensive abstract to come within the space available. What follows, therefore, is in the nature of a synopsis of the paper.

In the earlier stages of crane construction, wheels of the general design used in railroad service were adapted to crane service by adding a second flange of about the same section as that of a railroad wheel. This practice worked very well as long as the wheel loads did not exceed those used in railway service. In the heavy types of bridge cranes, however, concentrated wheel loads five times as great as occur in railroad service are required to secure the greatest economy.

The most common troubles with crane wheels are:

a. Wheels becoming out of round on account of unequal wear.

b Breaking down of metal on account of loads exceeding its bearing power

c Distortion and binding of flanges on account of irregularity in gage of track.

d These defects in wheels produce heavy strains throughout the structure, including worn and broken propelling gears.

All of these defects are not only annoying but expensive on account of the interruption of service of important machinery.

The Griffin Wheel Company has undertaken an investigation into these various phases by testing to destruction a large number of full size wheels of various designs in the R. W. Hunt & Company's 300,000-lb. Riehle testing machine. Use was also made of a considerable number of tests made at Purdue University and at the University of Illinois.

The items established are:

a The relation of the bearing power of chilled iron, to various types of steel rails.

[1] Griffin Wheel Co.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 20 to members; 40 cents to non-members.

b The carrying capacity of various rails.
c The relation of the diameter of wheel to traction.
d The relation of diameter of wheel to flange strength.
e The relation of flange thickness and tread thickness to flange strength.
f Standardization of designs for all diameters of crane wheels.

Bearing Power of Chilled Iron on Steel Rails. The vertical load to be carried on any wheel is not limited by the capacity of the wheel, but by the carrying capacity of the rail. The bearing power of chilled iron

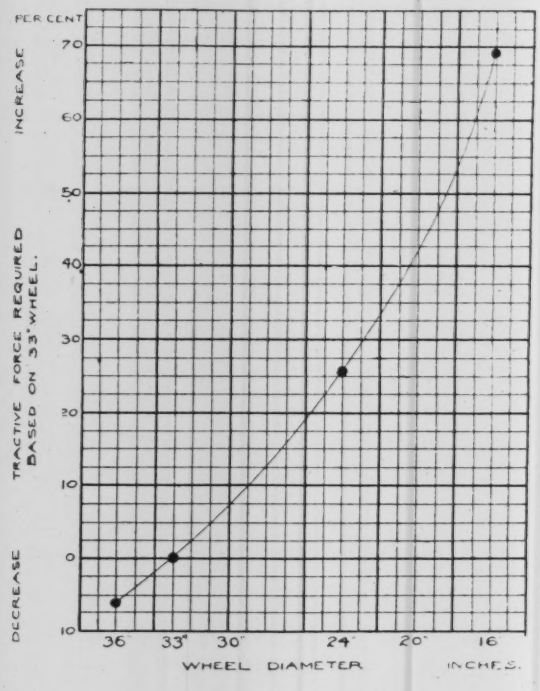


FIG. 1 PERCENTAGE OF TRACTIVE FORCE REQUIRED FOR VARIOUS DIAMETERS OF WHEELS COMPARED WITH 33-IN. CHILLED IRON WHEELS

is far in excess of that of a steel rail, and, therefore, may be neglected when considering maximum vertical loads.

The tests show that under like loads, the depression in the rail is inversely as the diameter of the wheel. The larger diameter of wheel makes a larger area of contact, which reduces the pressure per square inch.

The following table shows that the mean intensity of the stress over the area of contact was about 100,000 lb. per sq. in. for the chilled wheel and 86,000 lb. for the steel driver.

Analysis of the Carrying Capacity of Various Rails. Tables are given to show that on a new A.S.C.E. rail the safe maximum limiting load for a 12-in. wheel is 23,000 lb., and for a 33-in. wheel, 38,150 lb. If the top of the rail is flat, 2 in. wide, the limiting load on 12-in. wheels is 78,300 lb. and on 33-in. wheels, 130,000 lb. One of the tables gives also the carrying capacity

TABLE 1 CONTACT AREAS AND PRESSURES

Load in Lb.	33-In. Chilled Wheel		44-In. Steel Driver	
	Contact Area	Pressure per Sq. In.	Contact Area	Pressure per Sq. In.
5,000	0.07	71,500	0.07	71,500
10,000	0.12	83,300	0.15	66,700
15,000	0.16	93,750	0.19	79,000
20,000	0.22	90,900	0.25	80,000
25,000	0.27	92,600	0.30	83,300
30,000	0.35	85,750	0.36	83,300
40,000	0.40	100,000	0.47	85,000
50,000	0.44	113,600	0.50	100,000
60,000	0.57	105,000	0.68	88,300

of the rail only, without reference to the strength of the wheel.

Relation of Diameter of Wheel to Traction. The power required for locomotion decreases as the diameter of wheel increases.

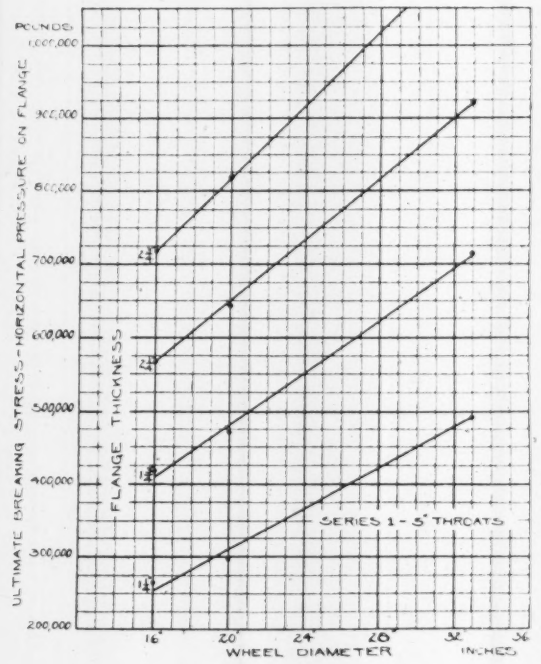


FIG. 2 CURVES SHOWING EFFECT ON FLANGE STRENGTH PRODUCED BY INCREASE IN WHEEL DIAMETER

A 24-in. wheel requires 25 per cent more power than a 33-in. wheel.

A 16-in. wheel requires 68 per cent more power than a 33-in. wheel.

Fig. 1 shows graphically the relation between the variation in the diameter of wheel, and tractive force required. It appears that the 24-in. wheel would require 25 per cent more power and the 16-in wheel 68 per cent more power than the 33-in. wheel under these conditions.

As regards the safe loads and deflections of rails. From the bearing tests made, the average depression due to bearing alone was 0.0029 in. per 10,000 lb. load:

$$0.0029 \times 13.7 = 0.0397$$

Combined deflection and depression, 0.0497.

Relation of Diameter of Wheel to Flange Strength. The strength of flanges increases with the increase in diameter of wheel. With the same dimensions of flange and tread the flange on a 33-in. wheel is from 26 per cent to 34 per cent stronger than the flange on a 24-in. wheel and from 62 per cent to 92 per cent stronger than the flange on a 16-in. wheel.

The failure of wheels occurred in what may be called two stages. The first failure represents the ultimate strength of the chilled or white iron. The ultimate failure represents the rupture of the grey iron. The coefficient of elasticity is evidently different in the two kinds of iron, and the necessity for backing up the chilled iron with grey iron is clearly indicated. The curves in Fig. 2 show that from the $1\frac{1}{4}$-in. flange to the $2\frac{3}{4}$-in. flange, the rate of increase in strength is higher with each successive flange thickness.

Relation of Flange Thickness and Tread Thickness to Flange Strength. The tests show that the relation of flange thickness to throat thickness for crane wheels should be as two is to three. Assuming the strength of a flange $1\frac{1}{4}$-in. thick and throat thickness of $1\frac{7}{8}$ in. as 100, a flange having a thickness of $1\frac{3}{4}$ in. and throat thickness of $2\frac{5}{8}$ in. would be 200. In other words, every $\frac{1}{8}$ in. added to flange thickness with the relative increase in throat thickness increases the flange strength 25 per cent. Chilled iron flanges were tested to above 1,000,000-lb. horizontal pressure without breaking.

The value of chilled iron for wheels to carry the heaviest concentrated loads is being more and more recognized. This is shown in crane work and other locations where loads of 100,000 lb. and upwards are required per wheel. An inquiry from a U. S. Navy Yard for 38-in. wheels for use under a heavy traveling crane reads as follows: "The steel wheels have been so unsatisfactory that it led us to inquire of you relative to the furnishing of regular chilled cast iron wheels for this purpose." Chilled iron wheels were furnished and have served with satisfaction for three years. This indicates that for heavy concentrated loads, chilled iron has superior qualities, and that the only limit to car capacity is the ability of the rail to carry the load.

Heretofore a good many crane builders have used the standard M.C.B flange on wheels for crane service. This certainly is not correct, for in railroad service the thickness of flange is limited on account of crossings, switches, guard rails, etc., while in crane service, where the load carried by the wheel and the resulting flange pressure is several times greater than encountered in railroad service, there is unlimited space for designing flanges in proportion to the work which they must perform. Furthermore, for heavy cranes where the expense of changing wheels is large, and in case of renewals keeps the crane idle, an ample factor of safety should be used. This is also essential on wheels having two flanges, when the rail is out of level, giving excess work on one wheel, or the track is out of alignment, which changes the track gage, and one flange receives considerably more stress than calculated.

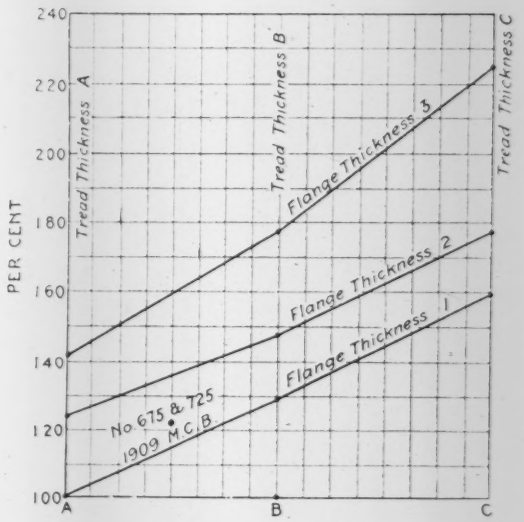


FIG. 3 RELATIVE STRENGTHS OF FLANGES FOR VARIOUS THICKNESSES

Standard Design for Crane Wheels. Various designs of 12-in. to 36-in. double flange wheels were made, giving the maximum safe vertical load and the maximum safe flange pressure for each design. Full details of each wheel are shown in the paper.

The maximum vertical load given does not exceed the maximum stress that should be applied on the various steel rails shown in connection with the wheels.

In analyzing the metals available for the manufacture of wheels for crane service, the definite conclusion is reached that chilled iron has more desirable properties for heavy wheel service than any other known metal for the following reasons:

a Sufficient bearing strength to sustain the heaviest load imposed.

b Chilled iron does not crystallize and is free from structural defects.

c Has high resistance to abrasion and distortion under heavy pressures on the small area of contact between tread and rail.

d The chilled iron tread, on account of the absence of ductility, and coupled with the slow wearing qualities, retains the rotundity of the wheel to a larger extent than can be obtained with any other metal.

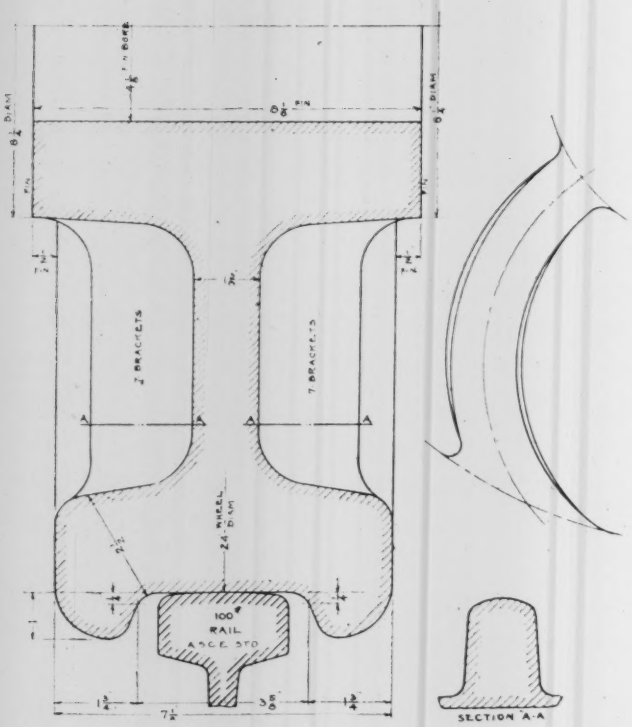


FIG. 4 24 IN. 640 LB. DOUBLE FLANGE CHILLED IRON CRANE WHEEL, SINGLE-PLATE TYPE

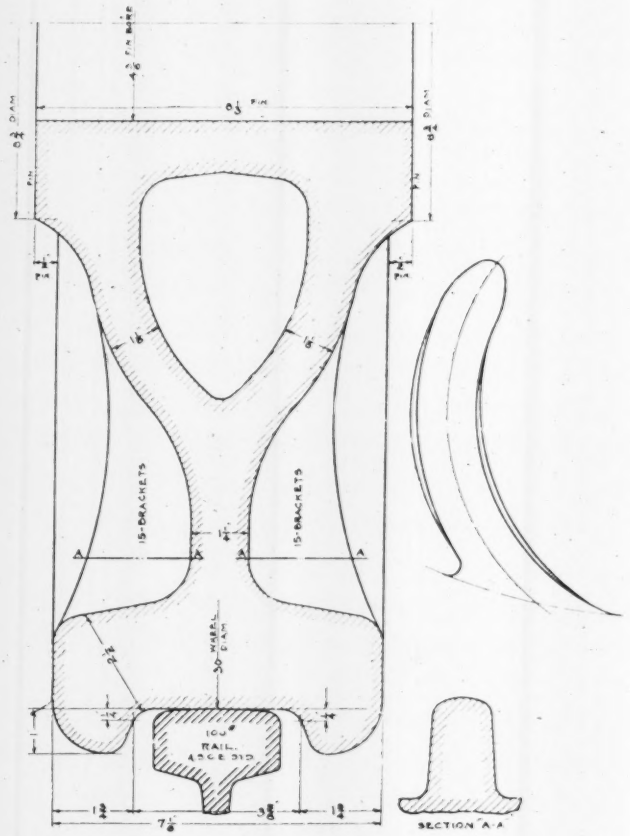


FIG. 5 30 IN. 875 LB. DOUBLE FLANGE CHILLED IRON CRANE WHEEL, DOUBLE-PLATE TYPE

e Flanges have high wearing qualities and when designed properly have sufficient strength to withstand all side thrusts imposed.

f Flanges of chilled iron produce far less abrasion on steel rail than if made of steel.

For consistent design there should be a fixed relation between flange thickness and throat thickness. Stated as a proportion, flange thickness is to throat thickness as two is to three. Stating this relation in another way—the addition of ½ in. of metal to the flange is equivalent to adding ¾ in. of metal to the throat.

With wheels of different diameter, the flange strength varies approximately as their diameters, other conditions remaining the same. The addition of ½ in. of metal to the flange of a wheel or ¾ in. to the throat of a wheel raises its strength to the 1.028th power.

In general the results obtained demonstrated that it was possible to design wheel flanges of chilled iron with absolute certainty that they would safely carry loads far in excess of the greatest used in present day practice.

That the limit of the bearing strength of the wheel itself is far in excess of anything that has yet been built was shown by tests made on 12-in. and 16-in. single plate wheels from which the flanges had been broken. Loads of 300,000 lb. were applied on the tops of these wheels without an appreciable deflection or flattening of the surface of the tread. This load was carried entirely by the plate and brackets of the wheel without any support from the flanges.

Table 2 gives the safe strength of crane wheel flanges, using a factor of safety of five.

Fig. 3 shows, on the basis of the tests, the relative increase in strength of flanges for various thicknesses of flanges and tread sections. The inner lines are the contour of the 625 lb. M.C.B. flange and tread. Lines 2 and 3 are ¼ in. and ½ in. increase in flange thickness, and lines *B* and *C* are ½ in. and 1 in. increase in thickness of tread.

TABLE 2. SAFE STRENGTH OF CRANE WHEEL FLANGES AT A FACTOR OF SAFETY OF FIVE

Diameter Inches	Flange Inches	Throat Inches	Rail, Lb.	Strength
12	1	$1\frac{1}{8}$	40	3,000
	$1\frac{1}{4}$	$1\frac{1}{2}$	50	5,000
	$1\frac{1}{2}$	2	60	8,000
20	1	$1\frac{1}{2}$	50	8,000
	$1\frac{1}{4}$	$1\frac{7}{8}$	60	11,000
	$1\frac{1}{2}$	$2\frac{1}{4}$	80	15,000
24	$1\frac{1}{4}$	$1\frac{3}{4}$	60	12,000
	$1\frac{1}{2}$	$2\frac{1}{8}$	80	18,000
	$1\frac{3}{4}$	$2\frac{1}{2}$	100	25,000
30	$1\frac{1}{4}$	$1\frac{3}{4}$	60	16,000
	$1\frac{1}{2}$	2	80	22,000
	$1\frac{3}{4}$	$2\frac{1}{2}$	100	32,000
	2	3	100	47,000
	$2\frac{1}{4}$	$3\frac{1}{2}$	150	69,000
36	$1\frac{1}{4}$	$1\frac{3}{4}$	60	20,000
	$1\frac{1}{2}$	2	80	26,000
	$1\frac{3}{4}$	$2\frac{1}{2}$	100	38,000
	2	3	100	56,000
	$2\frac{1}{4}$	$3\frac{1}{2}$	150	86,000

DISCUSSION

ARTHUR L. WILLISTON in commenting on the method described of finding the power required for locomotion by drawing a load up an inclined plane, called attention to the question of the friction of rolling between a smooth ground wheel and a smooth rail. The author had calculated this on the theory of the wheel running uphill. If the material were like lead, which is absolutely inelastic, that would be a correct way of calculating, in making the successive depressions in the rail as the wheel moves forward. With an elastic material like chilled iron, the condition is somewhat different. There is another force behind the wheel tending to push the wheel forward as the material tends to return to its natural condition. With a material like chilled iron running on an open hearth steel rail, from one-half to two-thirds of the work done in compressing the rails is returned by the elasticity of the materials.

W. A. BENNETT[1] who presented the paper in the absence of the author said in reply that the chilled iron used is so hard that it has no ductility whatever; while it is not claimed that the theory of a body rolling up an inclined plane is absolutely correct, it gives a result within working limits.

W. L. STORK[2] in a written discussion accompanied by lantern slides showing microphotographs of the structure of chilled iron car wheels said that chemical analysis and condition of casting are equally, if not more, important in the standardization of crane wheels than standardization of design. The design can have no positive influence upon the quality of wheel if the condition and composition of the iron put into the wheel are not studied.

The chemical analysis of the metal and length of time in service of the wheels are given in Table 3.

The microphotographs showed the structure of four different wheels two of which gave excellent service and two lasted only a few months. They showed that there is a difference in structure in each wheel in passing from the chilled sections to the softer sections. Those of the good wheels show the metal hard, strong and dense. The metal of the other two wheels has a different structure. The chilling action also in the two good wheels was more severe and to a greater depth. With respect to the chemical analysis shown in the table, it is to be noted that the manganese, phosphorous and sulphur contents are the same for all wheels.

The higher the carbon content the greater the tendency for a graphitic structure; also the higher the carbon content the less is the change of chilling the casting. For high carbon contents the cooling and freezing cannot be rapid enough to retain all of the carbon in the combined form. Does not the chemical analysis and composition justify the metallography as shown in the photomicrographs? Are not the increase in graphite, the coarser structures and the decrease in cementite justified by the chemical composition?

TABLE 3. COMPOSITION OF WHEELS AND TIME IN ACTUAL USE

ALL WHEELS REMOVED DECEMBER 1, 1911

No.	Total Carbon	Si.	Mn.	P.	S.	Months in use
2	3.00	0.65	0.40	0.440	0.137	36
22	3.22	0.45	0.53	0.296	0.124	8
13	2.60	0.52	0.51	0.390,	0.140	118
18	2.62	0.50	0.53	0.300	0.153	111

AUGUSTUS SMITH, in a written discussion, stated that, though the author's paper is not always convincing, the tests on the strength of flanges is valuable, and the suggestion that crane wheels should be designed according to the strength of the flange seems to be a very logical method. Nevertheless the method of designing the wheel outlined can be followed for any agreed upon ratio of horizontal flange stress to vertical wheel load.

No experiments were made on tractive force. The tractive force required for wheels of different diameters is derived by the author by a mathematical analysis which neglects the elastic properties of the rail and wheel in regaining their respective contours after the load is relieved or passes along, which shifting of the load to successive portions of the rail and wheel even aids in restoring the depressed contour. In the writers opinion, the results given are incorrect.

A line of investigation is suggested which would be a more accurate method of testing rail and wheel resistance to vertical loads; tests in which the tractive force required to roll wheels on rails under different loadings and different diameters of wheels is measured directly. Tractive force should vary with the load and be practically independent of the diameter of the wheel, after correction for journal friction, as long as the rail and wheel are perfectly smooth and the load does not exceed the elastic limit of either rail or wheel. If such tests were made with a glass-like unyielding wheel, the results would indicate the elastic limit of the bearing power of the rail. Another series of tests on a special rail of glassy hardness would indicate the elastic limit of the bearing power of different wheels made of softer material than the test rail.

[1] Griffin Wheel Co., Chicago.

[2] 212 Hancock Ave., Jersey City, N. J.

THE MECHANICAL ELIMINATION OF SEAMS IN STEEL PRODUCTS, NOTABLY STEEL RAILS

BY ROBERT W. HUNT, CHICAGO, ILL.

Member of the Society

Increased weight of rolling stock and speed of traffic have led to increase in size of rail sections, requiring changes in the detail of rail manufacture. Under these conditions it is not surprising that new and unexpected physical weakness should develop in the heavier rails. One of the chief troubles has been failures through

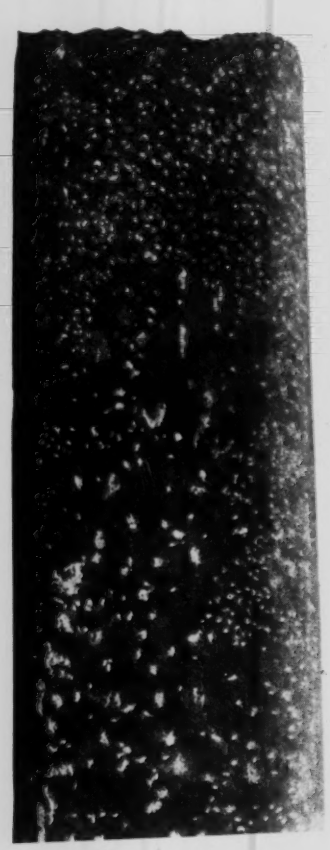


FIG. 1 FACE OF AN INGOT AFTER HEATING WITH THE ADHERING SCALE REMOVED

crescent-shaped pieces breaking out of the rail flanges, followed by at least one, and in many cases several, ruptures across the whole section of the rail. Investigation showed that in practically every instance of such failure there was a more or less pronounced seam running longitudinally in the bottom of the rail near its center. This seam occurs at the top of the curve of the crescent-shaped break and is undoubtedly the point at which the fracture starts.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to nonmembers.

As a result of an investigation of the subject, T. H. Mathias, assistant general superintendent of the Lackawanna Steel Company, determined that the most certain way of getting rid of seams was to remove that portion of the metal which contained them. He reasoned that the primary causes of seams existed in the ingots and probably were incident to the casting of the ingots. The surfaces of ingots display disk-like apertures, due to entrapped air, which in rolling could easily be elongated into dangerous seams. It was demonstrated, also, that the surfaces of the ingots are decarburized to the extent of eight to ten points carbon and to a depth of 5/16 in., which must be detrimental to the finished product.

The removal of the surface metal is effected by a hot sawing, or milling operation during the process of rolling. The ingot is first reduced to a point where the product is 75 per cent finished, in the form of a partially shaped bar 60 ft. long, when it is entered between two pinch rolls with the flange side up and forced between two milling saws. A second set of rolls pulls on the bar and aids in holding it in line for the milling operation, for which purpose milling saws 5 ft. in diameter are used. Metal

FIG. 2 EFFECT OF PRACTICALLY ROUND IMPERFECTIONS WHEN ELONGATED BY 15 PASSES IN THE ROLLING MILL

is removed from the top and bottom of the bar, the main object being to eliminate the seams from the central portion of the bottom of the rail which has been the starting point of the moon-shaped failures, and to remove them from the top or bearing surface of the head of the rail.

In Fig. 1 is reproduced a photograph showing the actual size of a section of the face of an ingot as it appears after heating with the adhering scale removed. This view gives an illustration of how serious the disk-like apertures in the surface may be. As the section of the ingot is reduced and elongated in the rolling process, the apertures will be stretched longitudinally and formed into seams. Fig. 2 shows what would occur in that way to any practically round imperfections of the size indicated when elongated by 15 passes in the rolling mill. If so small an imperfection would give such a result, the seams resulting from larger ones would be proportionately greater and, therefore, more serious, both in length and depth.

In the operation of rolling, the ingot is reduced in the blooming rolls to an 8-in. by 8-in. cross-sec-

tion and after cropping the ends the bloom is further reduced in the roughing or shaping stand of rolls by five passes. A bar which will make four 33-ft. rails is at this point in the rolling operation about 60 ft. in length; therefore, the area of metal to be cut off or removed in the milling machine is approximately 1/8 in. deep, 7 in. wide and 60 ft. long. It is driven through the pinch rolls at a rate of 60 ft. in 30 seconds. The pinch rolls have a draft of about 3/8 in. and thus force the bar between the two milling saws, which are so arranged in the housing that they may be raised or lowered as desired. There is from 1/32 to 3/64 in. of metal milled from the head and base of the bar, the front end of which, immediately on passing from between the tools, is caught by a second set of pinch rolls which have a draft of about 1/16 in. These pinch rolls force the bar between the tools, pull it from between them, and also hold it in practically perfect line for the milling operation. The milling apparatus is driven electrically and requires about 600 h.p. for its operation.

Fig. 3 shows an etched cross-section of the piece preparatory to its entering the milling machine, and on it is clearly shown the enveloping layer of lower

FIG. 3 CROSS-SECTION OF BAR PREPARATORY TO ENTERING MILLING MACHINE

carbon steel. Fig. 4 presents the shape of the bar after it leaves the milling machine preparatory to further reduction in the regular rail rolls.

Fig. 5 shows the milling operation in process. As the milled dust or particles of steel are thrown out, they are hit by water under pressure which forces them into a chute which discharges them below and also prevents the material from adhering together. Fig. 6 shows one of the milling tools. It is 5 ft. in diameter with an 8 in. width of face and revolves at a peripheral speed of 2500 ft. per minute, thus causing an engagement of about 400,000 teeth per minute on the hot rail bar. The teeth are 0.80 carbon steel, and it has been demonstrated that they will mill at least 30,000 tons of material without requiring dressing. The one shown had milled about 15,000 tons.

Fig. 7 shows a piece of a rail broken under the drop press in which is plainly seen a pronounced seam in the flange directly under the center of its base, and is an illustration of a dangerous rail.

To illustrate the appearance of many ordinary steel rails of commerce when etched the author shows a collection of photographs of heads and flanges of rails of several different makers, including specimens

FIG. 4 APPEARANCE OF BAR AFTER IT LEAVES THE MILLING MACHINE

from the Lackawanna Steel Company which have been milled by the Mathias process. Four views are reproduced herewith in Figs. 8 and 9 which are characteristic and representative of those given in the paper.

DISCUSSION

H. C. HIBBARD felt that the paper might be considered as curing a thing which ought not to be present at all. More of the seams are the result of rubbing, but undoubtedly, at least some of them have started from those surface skin holes which really ought not to be there in good steel. The speaker stated that he is still old-fashioned enough to agree with Captain Hunt, who said once that he believed the way to make good steel, was to make good steel. Formerly, good steel used to be made by proper furnace management, proper care of the gases and proper care of the impurities; and ingots were made such that rails rolled from them were actually perfect and showed no seams. Split, there was nothing to them but clear, sound, solid steel from one end to the other, and from top to bottom, so that they did not require to be milled to be free from seams. None of the rail ingots which represent current practice are sound. They all have pipes and a number of them have blow-holes. The speaker realizes the difficulties which rail mills have to meet owing to the plants which they have, to produce solid ingots, but at the same time, he believes that until that is done and until the production starts with the solid, sound ingot, it will be impossible to get a sound, solid rail.

Properly made steel should have a full liberty to pipe and the pipe should not be reduced or eliminated by holes in the other parts of the ingot. In an ingot cast without any spe-

cial precautions, the only hole that should be there should be the pipe and nothing but the pipe. There are two well tested means of getting rid of the pipe and of securing a sound ingot. One is by lateral pressure, and the other by keeping the top of the ingot hot. A rail ingot will probably keep melted in the interior from 1¼ to 1½ hr. according to its size, after it has been cast, and whatever means is applied to prevent the pipe, it should probably start within fifteen minutes after the ingot is cast and should be continued until the metal is all solidified. This being properly done, there will result a good, sound ingot, and such an ingot properly rolled will give a rail without seams.

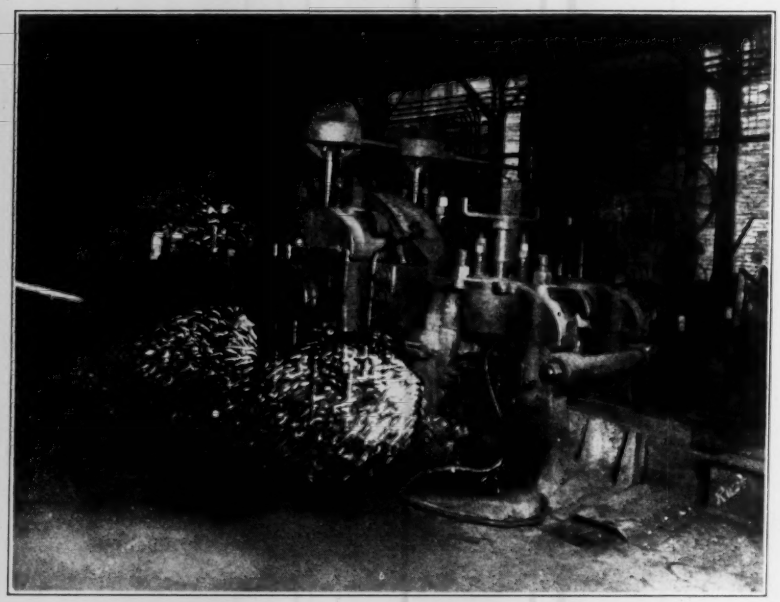


FIG. 5. HOT SAWING OR MILLING MACHINE IN OPERATION

J. D. HOWARD, in a written discussion, pointed out that the report of the Committee on Rails and Equipment of the National Association of Railway Commissioners, presented at its recent convention held in Washington, D. C., in dealing with the subject of train accidents, furnished statistics from which it appears that the average daily losses due to derailments alone, for a term of 10 years, were at the rate of 1.04 persons killed, 14.4 persons injured, and a property loss of $15,900 per day. The total figures were 3,727 killed, 52,047 injured and property loss of $57,192,396.

An amelioration of such conditions is demanded and it is believed that milling the running surfaces of the heads and the lower surfaces of the bases of steel rails will remove certain recognized defects, and thereby tend to lessen the number of rail failures and the casualties incident thereto. It is understood that no claim is made for other than surface defects. The writer had witnessed the process of milling the bars and Mr. Mathias, who made very modest claims for it, expects that milled rails now in service will within a short time demonstrate the efficacy of the method.

The presence of streaked metal in rails, including both interior and exterior streaks, and low carbon surface metal, have occasioned comments in reports upon tests of steel rails. Such a soft metal surface when located over a hard steel core and exposed to wheel pressures at the running surface of the head, exerts an unfavorable influence, particularly when interior seaminess is present. It augments the wedging and splitting tendency of the wheel loads. Still earlier, Tests of Metals, 1909, showed a difference of 28 points in carbon between the center and the sides of the head of a 75 lb. rail.

Such occurrences are common and their frequency constitutes a sufficient basis for the claim advanced by Mr. Mathias that one of the features of his process consists of the removal of partially decarburized metal at the surface. There is less anxiety on account of the presence of decarburized surface metal at the base than at the head of the rail. Soft steel may even display the functions of a deterrent against the detrimental influence of seaminess in such places. Certain defects are negligible in soft steels which are serious in hard steels, such as slight serrations and indentations.

Streaky conditions in steel doubtless constitute serious problems for the steel maker. Such streaks are the cause of many rail failures, and they should be eliminated if it is feasible to do so. They tend to cause split heads and base fractures. The removal of such seams is a metallurgical question, in respect to which the steel makers do not offer great encouragement. Still, the case may be more hopeful than some statements would lead one to infer. Present information indicates that a more general state of interior seaminess exists in "A" rails over those of other parts of the ingot.

Referring to the investigation of rails conducted by the Commission, the metal of the heads and bases of a number of rails have been planed off to different depths, and a streaked state disclosed at each stage. Starting at the ingot, there is obviously no reason for expecting any different metal on the side which chances to become the head of the rail

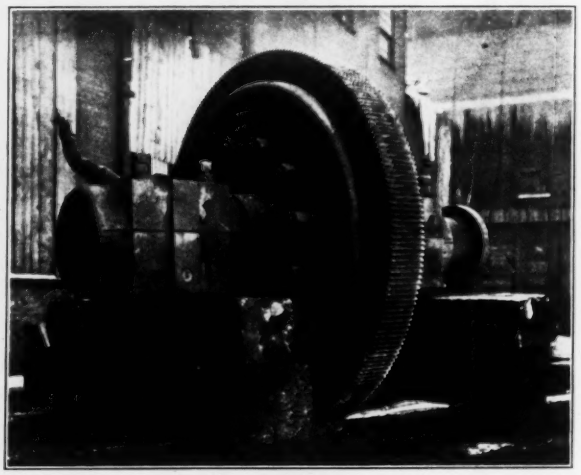


FIG. 6 A VIEW OF ONE OF THE MILLING TOOLS

over that which happens to be rolled into the base. Interior streaks in the metal of the head should have their counterpart in the metal of the base.

The examination of the metal in a 100 lb. rail of recent manufacture, an "A" rail, showed the presence of 22 seams in the metal of the head, ranging in length from $\frac{1}{2}$ in. to $5\frac{1}{2}$ in., and at various depths up to $\frac{3}{4}$ in. Some were at the surface, but generally they were most prevalent at depths of $\frac{1}{8}$ in. to $\frac{3}{8}$ in. below the running surface. Those of the base were found at depths up to $\frac{9}{16}$ in. measured from the lower surface, lengths from $\frac{1}{2}$ in. to $7\frac{1}{2}$ in., and in from the edge of the flange 1 in. to $2\frac{3}{4}$ in. Twenty-three of these base seams were disclosed in this rail. Other rails from other heats and other parts of the ingot were free from interior streaks, so far as disclosed by the examination.

M. H. WICKHORST[1] expressed his admiration of the bravery of Mr. Mathias in getting up a milling machine that will mill a hot bar 60 feet long and do it while the bar is going through the rollers. He believes, however, that the cause of the seams in the rail is somewhat different from what Captain Hunt stated it to be. The deep seams in the rail flaws which extend anywhere from 0.08 to 0.12, or possibly 0.15 of an inch deep from the surface, seem rather to start from cracks in the ingot. If the scale is removed so that the surface can be really seen, it becomes apparent that most ingots are more or less cracked. When the ingot is rolled, the seams tend to crack open, and the amount depends upon the draft in the rolling. With a large draft, this crack will open wide and there will be in the surface of the bloom a sort of a double "V"-shaped affair. This zigzag shaped crack opens up in the first pass, and in the next passes, the crack will modify into a double "V"-shaped flaw, one inside the other. Further rolling simply presses them together so that at the stage of the bloom 8 to 10 in. sq., there will be a flaw which looks like a "Y," the two sides having come together and some of the "V" flaw still remaining. Still further rolling will simply extend the "Y" flaws in the bloom, so that when they come to a rail, or a small billet, there will be a very much elongated "Y," or generally a series of them together.

An interesting fact is that it seems that these flaws occur mostly on what are known as the two open sides of the ingot as it first enters the rolls. On the top and bottom sides, where actual compression is applied, the ingot probably tends to heal up. In this way, it may be possible to manage so that these seams will occur mostly in the thread, or the bottom, or the base of the rail, and the thought has occurred further that this can be made use of practically. Apparently seams that occur in the web, or top of the head, do not result in rail fracture, while those which occur in the base near the center under the web, do result in rail fractures, and as nearly as the speaker could determine, about 40 per cent of the rail failures in this country have on the average their origin in these deep seams at the base and particularly near the center.

P. H. DUDLEY[2] in a written discussion called attention to the fact that the adoption of basic open hearth steel for rails had reduced the breakages and failures to a marked extent. The checking of the basic open hearth ingots in blooming is not nearly so frequent as in Bessemer ingots, and half-moon or crescent shaped brakes have been reduced in the same sections of rails by nearly 50 per cent. Over three decades ago some railroad companies have designed stiffer sections with a better distribution of the metal so as to carry heavier wheel loads with lower unit stress. Service tests in the track demonstrated that with the higher standards of track secured by the stiffer and heavier sections, and under an increase of wheel loads and higher speed, mechanical abrasion of the cross ties under the rail, the disturbance of ballast and roadbed, were less than under the early light rails and lighter wheel loads, and there was also a reduction of rails in service for the tons carried. Of course the rail sections of three decades ago could not be expected to be adequate to meet the present heavier wheel loads, and three to four times the volume of traffic. Weight is but one

FIG. 7 PIECE OF RAIL BROKEN UNDER THE DROP PRESS

element of steel rails and it must be distributed so that the combined mechanical and physical properties resulting from a good design, and the metal will be capable of not only meeting the intensities of the wheel contact pressure, but also carry and distribute their wheel loads to the frequent supporting cross-ties, ballast and road-bed.

The type of rail section for an economic and efficient engineering structure, must have the metal distributed in sufficient width of head to maintain large wheel contacts and moderate intensity of pressure on the bearing surface of the head. It is a misconception of the relations of the wheel contacts on the bearing surface of the rail heads to assume that as the wheel loads have increased the areas of the contacts between each have been reduced by the recent coning and shape of the wheel tread contours. The Pennsylvania Railroad Company has made their new 125 lb. rail for trial with a 3-in. wide head, while the New York Central and the

[1] Eng. of Tests, Rail Committee, Am. Ry. Engrg. Assoc., Chicago.
[2] Consulting Eng., Grand Central Terminal, New York.

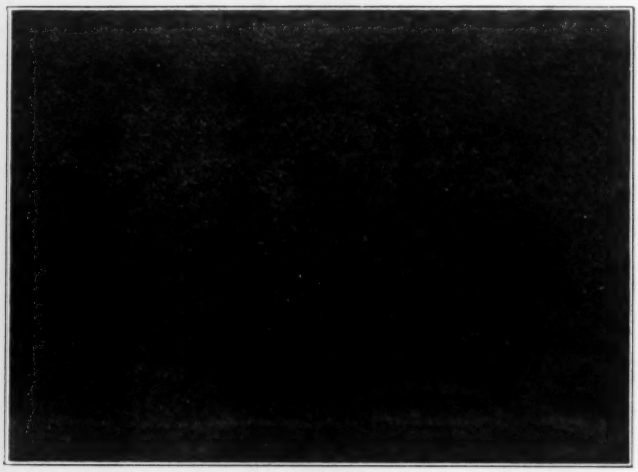
Boston & Albany Railroad Companies have each used a rail head 3 in. wide for twenty-two and twenty-three years respectively.

Consumers of rails hope that soon there will be installed less injurious methods of straightening the rails of stiffer sections than those now in use. Deep ragging of the blooming rolls must also be considered, for it has been found that where rails are rolled with lighter passes and diagonal roughing, the cracks in the bases of the rails are less than where the drafts in the blooming passes are heavy and their ragging deep.

The writer congratulated Mr. Mathias on the introduction of his "hot miller" as a step in advance in rail manufacture, which is also a proof of the manufacturers' efforts to eliminate the slight defects in their products, so that they will meet all of the exacting conditions of present service.

THE AUTHOR in conclusion said that he fully agreed in regard to the necessity for making sound ingots. He had not departed from his "old-fasioned" position in regard to that; but as long as sound ingots are not generally made, it is a good thing to try as far as possible to ameliorate their bad effects. This process will not remove deep seams. It will simply eliminate a certain class of seams which occur in practice however careful the manufacturer may be and it will remove the decarburized skin. This process removes the superficial seams after which, if the inspector still finds defects of this character he knows he has a deep seam and ought to condemn the rail.

TOP SURFACE



TOP SURFACE

BOTTOM SURFACE
FIG. 8 UNTREATED RAIL

BOTTOM SURFACE
FIG. 9 MILLED RAIL

CEMENT SESSION

FOLLOWING the custom of previous meetings, the Cement Session was an informal gathering of those interested in cement manufacturing held in the rooms of the Society on the eleventh floor. There were about twenty in attendance. The author, Mr. Porter, illustrated his paper during its presentation with stereoptican views. After the presentation of the paper, the author answered a number of questions and an informal discussion was participated in. There was no stenographer present, however, and the discussion was not made a matter of record.

ELECTRIC DRIVE FOR ECONOMIC OPERATION AND DEVELOPMENT OF CEMENT MILLS

BY J. BENTON PORTER, PHILADELPHIA, PA.

Member of the Society

Electricity was first used only for lighting in cement plants; next it was employed to drive machinery located in inconvenient places; then it was used for driving the auxiliary apparatus, and it later enabled the manufacturer to locate this auxiliary apparatus more conveniently; next it provided more flexibility and greater output from the kilns; and finally, electrically is being universally adopted for the entire plant. The last five plants put into operation have installed individual motor drive and five other plants have changed to the electrical drive during the last two years.

A review of the reasons for this growth in the application of electricity to the manufacture of cement will be interesting:

a It enables the manufacturer to purchase power from central stations, thereby eliminating one of the greatest cost fluctuations from the cost of manufacturing cement.

b It gives a greater flexibility, permitting economical operation under varying conditions of output.

c It keeps the driven machine nearer to a predetermined speed, thereby increasing the output and maintaining the quality. As an example, one plant increased its output over 6 per cent by improving its speed regulation.

d The first cost and maintenance are no longer a nightmare to the management, as years of practical experience have shown that the advantages obtained have justified the cost and that the maintenance compared very favorably with the balance of the equipment.

e The electric drive has largely eliminated the human element, necessary in making reports, and automatically keeps a record of the power consumed in a plant with an accuracy that cannot be attempted with the mechanical drive.

Only a few managers have realized, or utilized one of the most contributory factors, namely, the various records that electricity can give. This paper is presented in order to call attention more strongly to the value of this salient attribute of electricity, by showing some of the records already compiled, and suggesting some of its future potentialities.

If it were possible to save one cent for every barrel of cement manufactured, how much money would a manager be justified in spending to obtain such an improvement? In a plant turning out 1000 barrels a day, the saving would amount to about $3600.00 a year, and such a plant would be justified in borrowing about $20,000.00 in order to accomplish such a saving. Similarly, a 5000 barrel plant could afford to expend about $100,000.00.

The manufacturer has already inaugurated different systems to find out where the weak points are in his process, but he has been badly handicapped, for he has had to base his records on reports that are not wholly accurate. The assumption that all his mills are running at their maximum capacity as long as they are in operation has to a very great extent been the ground plan; but accurate tests taken on any one machine show that it is almost impossible to keep a mill at a constant load and output, even when meters are installed and the feed regulated to keep the meter needle at a predetermined point.

The advantage of eliminating variables from the manufacturing of cement is apparent when we realize the variations in coal and the variables also shown in the manufacture of steam, which varies in evaporation from 4 lb. of water up to 10 lb. for each lb. of coal. It has also been pointed out clearly that in the production of power from this steam where the consumption may vary from 30 lb. down to 12½ lb. and even lower; and even condensers vary depending on the volume and temperature of the water. These variables, as far as records have shown in cement manufacture, are by far the greatest.

The standard forms of contracts for the sale of power supplied by central stations call attention very strongly to the fact that the customer can purchase power more advantageously if his load factor is kept high. This means that if the daily readings of power required for the operations of the plant were plotted into a curve, this curve should come as near as possible to a *straight line*, since this condition would result in

Abstract of paper presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

many intrinsic advantages both to the customer and producer of power.

Fig. 1 shows readings taken of the power consumption in an electrically driven plant. The line *B* gives the average of these readings. The line *C* is determined by taking the total kilowatts consumed during the entire 24 hours and dividing this total by 24; and

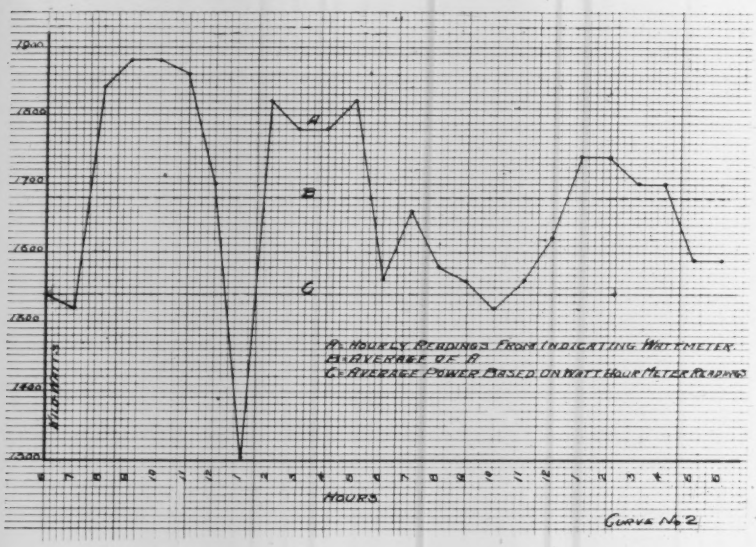

KILOWATTS
HOURS
B: HOURLY READINGS FROM INDICATING WATTMETER
B: AVERAGE OF B
C: AVERAGE POWER BASED ON WATT HOUR METER READING
CURVE No. 2

FIG. 1 POWER READINGS FROM ELECTRICALLY-DRIVEN PLANT

is, therefore, the only accurate record of the power consumed.

It is impossible to obtain a line like *C* from a mechanically driven plant and the difference between the lines *B* and *C* shows the possibility of error, even in the best records of the mechanically driven plant. In the latter, the basis for figuring the cost of power for the entire year has been periodical readings of indicator cards, and these have also been used to determine the amount of power it took in that particular plant to produce a barrel of cement.

The above calculations are based on the assumption that the power required to produce a barrel of cement is always constant, but this is absolutely incorrect. Fig. 2 shows the kilowatts consumed to produce a barrel of cement over a period of 31 consecutive days, and from this curve it is almost impossible to find two consecutive days where the ratio is constant. Thus it is not fair to compare the mechanical drive with the electric drive either in the cost of power or in the amount of power required to produce a barrel of cement.

Continuous operation has been and always must be the watchword for the cement manager. In addition to this he has always striven to run his machines at their maximum capacity. In other words, he has tried to keep his load constant and at the highest possible average, which, if illustrated by a curve, should show a *straight line*. From curves showing the power taken in different departments each day and over a period of an entire month, those that show the greatest variation from the average *straight line* are indicated, which are the departments that require the greatest study in order to bring them into the closest possible relation to the *straight line*.

By the installation of the individual motor drive, the separation of the various departments in the daily reports and the compilation of these records systematically arranged, the plant manager has a report which enables him to place his finger on any loose ends and even to anticipate where trouble may arise; to trace out an individual machine that is causing an over-demand of power, and after investigation to correct the trouble.

Records taken from tests of power taken in different departments will exhibit clearly an outline of the foundation of plans for improvement. The "Automatic Superintendent," which is to be used only as a base, enables the manager to make wonderful improvements, as it shows him where the improvements are most needed. No one can predict how great are the improvements that can be effected in the efficiency of cement manufacture. There is no general law that can be laid down for any particular class of mills, as the varied conditions of installation and the raw materials are so entirely different.

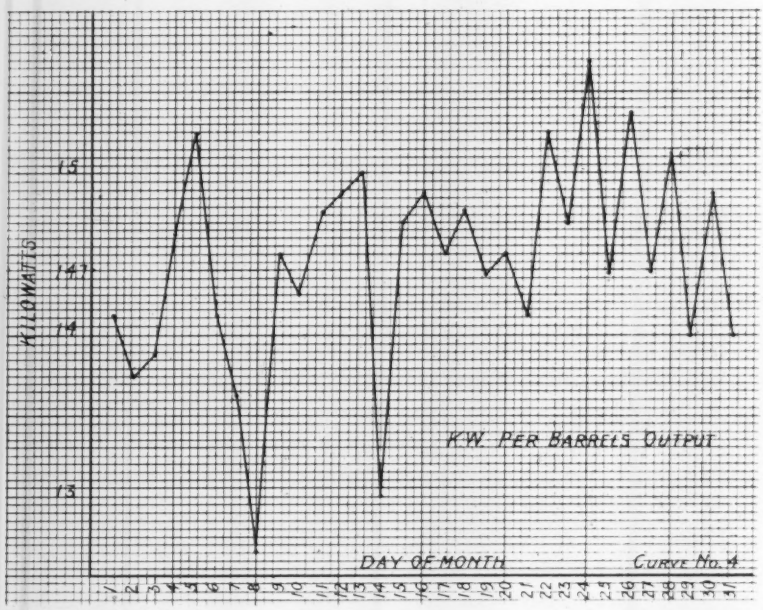


FIG. 2 KILOWATTS PER BARREL, CONSECUTIVE RUN

MISCELLANEOUS PAPERS

THE Friday morning session of the Annual Meeting, December 4, was devoted to a number of papers upon miscellaneous subjects as follows: A Rate-Flow Meter, by H. C. Hayes; Laboratory for Testing and Investigating Liquid Flow Meters of Large Capacity, by W. S. Gicle; A New Volume Regulator for Air Compressors, by Ragnar Wikander; Physical Laws of Methane Gas, by P. F. Walker; The Clinkering of Coal, by Lionel S. Marks; and Damages for Loss of Water Power, by F. W. Dean. The papers are here presented together with their discussions in abstract with the exception of that on The Clinkering of Coal, by L. S. Marks, which will appear in abstract form in the April issue.

A RATE-FLOW METER

BY H. C. HAYES,[1] SWARTHMORE, PA.

Non-Member

The velocity with which a fluid flows through a conduit can be determined by finding either its kinetic energy or its change in potential energy with respect to the direction of flow.

In the equation

$$H = \frac{V^2}{2g}$$

where V is the velocity of the fluid and g is the acceleration due to gravity.

The value of H is determined experimentally as the height the fluid is raised by the impact pressure. The pitot tube operates in accordance with this formula, and an application of the formula leads to Thompson's formula

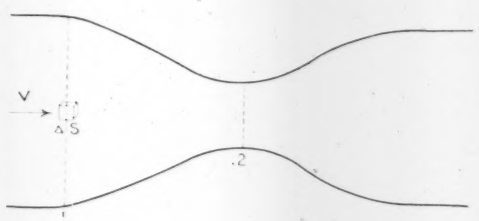


FIG. 1 SECTION OF CONDUIT OF NON-UNIFORM CROSS-SECTIONS

$$Q = K.H^{\frac{5}{2}} \text{ or } Q = K\sqrt{H^5}$$

where Q is the quantity which flows in one second through a V-shaped weir, K is a factor of proportionality, and H is the height of the water level above the bottom of the notch.

The relation between the velocity of the moving fluid and the change of pressure with respect to the direction of flow is obtained through Newton's Law of Motion, mass times acceleration equals the accelerating force.

In Fig. 1 consider the small element of volume ds^3 of the moving fluid having the front and rear faces perpendicular to the direction of flow. Let ρ be the density of the fluid supposed to be incompressible. Then from Newton's Law we have:

$$\rho \cdot ds^3 \cdot a = dp \cdot ds^2$$

where dp is the pressure difference at the front and rear faces. This simplifies to:

$$\rho a = \frac{dp}{ds}$$

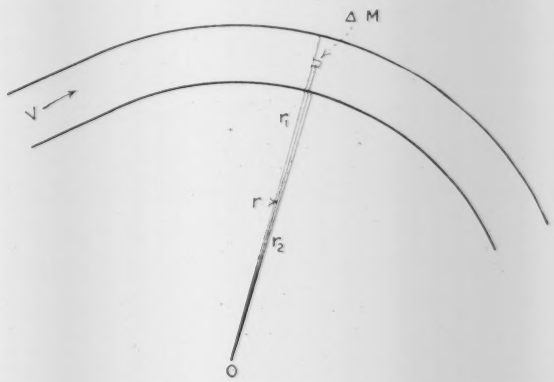


FIG. 2 CONDUIT BENT IN ARC OF A CIRCLE

Putting for a its equal $\frac{dV}{dt}$, and for ds its equal $V \cdot dt$, we get the following relation

$$V \cdot dV = \frac{1}{\rho} dp$$

Integrating this equation between the points 1 and 2 gives

$$\frac{\rho}{2}(V_1^2 - V_2^2) = P_1 - P_2$$

which states that the gain in kinetic energy is equal to the loss of potential energy.

Calling A_1 and A_2 the cross-section of the conduit at the points 1 and 2 respectively, we get through the law of continuity the relation

$$A_1 V_1 = A_2 V_2$$

This enables us to express V_2 in terms of V_1 and the equation becomes

$$\frac{\rho}{2}\left(\frac{A_1^2}{A_2^2} V_1^2 - V_1^2\right) = P_1 - P_2$$

By expressing the pressure difference in terms of head and the cross-sections in terms of diameter the equation simplifies to

[1] Prof. of Physics, Swarthmore College. The experiments were conducted at Harvard University, where Dr. Hayes was formerly connected with the Jefferson Physical Laboratory.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

$$H = \frac{V^2_1}{2g}\left(\frac{D^4_1}{D^4_2} - 1\right)$$

The venturi meter operates in accordance with this equation.

A trustworthy feedwater record is now looked upon as a necessity in all up-to-date steam plants, for it gives important information concerning the efficiency of the system. Such a record shows how many pounds of water are evaporated per pound of coal.

The meter described here was designed especially to give records showing such things as rate of evaporation of water per unit of coal, irregularities in boiler feed, leaks and slipping losses.

This meter operates through the relation which exists between the velocity of a moving fluid and the

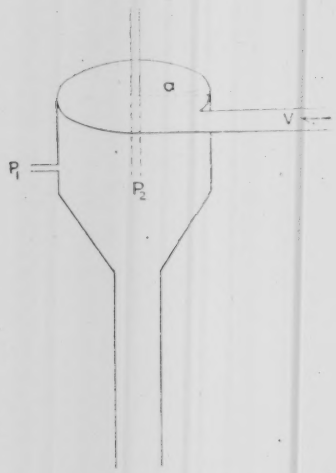


FIG. 3 CONDUIT SO SHAPED THAT A VORTEX IS FORMED IN THE MOVING FLUID

change of pressure in a direction perpendicular to the direction of flow. The pressure gradient in this direction is, of course, zero unless the flow lines are distorted. When these lines are made to describe the arc of a circle the relation is simple.

Suppose, in accordance with Fig. 2, the conduit is bent in a circular arc of outside radius r_1 and inside radius r_2. A difference in pressure will exist between points 1 and 2 due to the centrifugal force. A small mass dM at a distance r will give an increment of pressure dP outward along the radius such that:

$$dP = \frac{dM \cdot V^2}{g \cdot r}$$

The difference in pressure at the points 1 and 2 is given by integrating this expression from r_2 to r_1,

$$P_1 - P_2 = \int_{r_2}^{r_1} \frac{dM \cdot V^2}{gr}$$

If the fluid is incompressible,

$$dM = \rho \cdot ds^2 \cdot dr$$

and if we neglect the effect of viscosity, as has been done in obtaining all the formulæ, V will be independent of r and our expression becomes:

$$P_1 - P_2 = \frac{\rho \cdot ds^2 \cdot V^2}{g} \int_{r_2}^{r_1} \frac{dr}{r} = \frac{\rho \cdot ds^2 \cdot V^2}{g} \log \cdot \frac{r_1}{r_2}$$

and in order that P_1 and P_2 shall be the pressure per unit area, ds must equal 1. Making this change and writing $P_1 - P_2$ in terms of head we get the relation

$$H = \frac{V^2}{g} \log \frac{r_1}{r_2} = KV^2$$

and some idea of the value of K can be obtained by expanding $\log \frac{r_1}{r_2}$ in a series, which ultimately gives

$$\frac{D}{r} + \frac{1}{3}\left(\frac{D}{r}\right)^3 + \frac{1}{5}\left(\frac{D}{r}\right)^5 \ldots$$

where D = diameter of conduit and $r = \frac{1}{2}(r_1 + r_2)$.

If $\frac{D}{r}$ is less than 0.67 all but the first term of the series can be neglected and still leave the formula accurate to within 1 per cent. Giving $\frac{D}{r}$ this value we find that

$$K = 0.021$$

wherefore

$$H = 0.021\ V^2$$

A meter of this form works well for measuring large values of V, but is not sensitive enough for feedwater purposes. The factor of proportionality increases as r_2 is made smaller, but the higher terms can no longer be neglected, and when r_2 approaches zero the flow approaches more and more nearly to vortex conditions.

Suppose the conduit is so shaped that a vortex is formed, as shown in Fig. 3. The pressure difference between points 1 and 2 will approximate the value given by a circular vortex of the same cross-section and the value of the circulation corresponding to the velocity, V. The difference in pressure between the center and outside of a circular vortex of radius a is:

$$P_1 - P_2 = \frac{\rho K^2 a^2}{8\pi^2 a^4}$$

where K is the value of the circulation and is here equal to $2\pi aV$. Substituting this value and expressing the pressure difference in terms of head we have:

$$H = 0.5\ V^2$$

This result is but a rough approximation for the stream lines are spirals instead of circles, but the formula suggests that a sensitive meter might be constructed along these lines. Such a meter should not be greatly affected by fluctuations in pressure such as are always produced by feedwater pumps, for the inertia of the vortical mass will serve to steady the gage readings much as the flywheel does the motions of an engine.

Distortion of the entering stream lines through faulty connections or elbows placed too near the meter

will affect the readings but little as these distortions will become straightened in the vortex before the pressure terminals are reached. Finally, the sensitiveness of the meter can be changed by moving the low-pressure vent along a radius of the vortex and as a result the meter could possibly be made to give correct results for any particular temperature by setting the low-pressure vent properly.

This will be possible if the percentage correction in H caused by moving the low-pressure vent is independent of the flow; and if the correction so introduced is proportional to the distance the vent is moved, and the correction which is made necessary through change of temperature is proportional to the temperature change, then it follows that the meter can be made self-compensating by causing the low-pressure vent to be moved by an unequal expansion arrangement, providing the required motion is small.

Whether or not these conditions will be fulfilled can be predicted if the vortex is regarded as circular, for which it is shown that the percentage change in H is independent of K and therefore independent of V.

Calling $\mathbf{H}$ the change in H caused by moving the low-pressure vent a distance r from the center, we have for the relation between $\mathbf{H}$ and r

$$r^2 = \frac{8\pi^2 a^4}{K^2}\,\mathbf{H}$$

a parabolic and not a linear relation. Plotting this equation for different values of V, i.e., for different values of K, we have a family of parabolas, five of which are shown in Fig. 4. The change in H, caused by shifting the central vent a distance $\triangle r$, will be

$$\triangle H = \frac{d\mathbf{H}}{dr}\cdot\triangle r = \frac{K^2}{4\pi^2 a^4}\,r\cdot\triangle r$$

and if r is large with respect to $\triangle r$ the percentage change in r will be small and the change in H will be nearly proportional to the change in r, $\dfrac{\triangle H}{\triangle r} = \dfrac{K^2 r}{4\pi^2 a^4}$ a constant practically.

The change in r necessary to correct for temperature will probably be small, comparable to r_1 minus r_2 in the figure, and if the normal position of the low-pressure vent is a distance from the center r_1, then, as shown in the figure, the relation between r and H for values of r between r_1 and r_2 is nearly linear. Under these conditions we may assume that the correction introduced by changing r is proportional to the change.

It remains to consider whether the error caused by change of temperature is proportional to the temperature change. The error introduced by change of temperature arises from two sources: first, from the resulting change in the density of the liquid and the second, from the change in viscosity. These errors may or may not tend to neutralize one another depending on whether the meter is calibrated to give the flow in terms of weight or volume.

The calibration curve for the meter is

$$H = K\,V^a$$

and if H is expressed as pressure the equation becomes

$$p = \rho H = \rho K\,V^a$$

Calling p_c and ρ_c the pressure and density respectively at the calibration temperature, and p_t and ρ_t the corresponding values at some higher temperature t, we have the two equations

$$p_c = \rho_c K\,V^a$$
$$p_t = \rho_t K\,V^a$$

and if V, supposed here to be in terms of volume, is the same in each equation we have for the percentage error caused by the change of temperature:

$$\frac{p_t - p_c}{p_c} = \frac{\rho_t - \rho_c}{\rho_c}$$

And if we assume a linear relation between the density and the temperature, which is very nearly true, the error will be proportional to the change in temperature. This error will be negative since ρ_t is less than ρ_c, and must be corrected by moving the low-pressure vent toward the center.

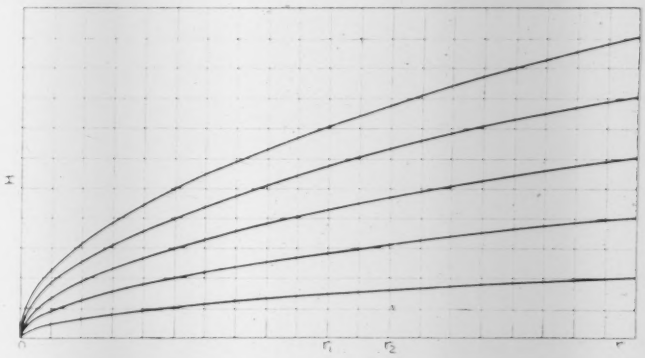


FIG. 4 FIVE CURVES OF THE FAMILY $H = K^2 r / 8\pi^2 a^4$

If the meter is calibrated for flow in terms of weight we have for the relation between V and W

$$W = k\rho V$$

where k is a factor of proportionality and W is the weight of flow per second. The calibration equation becomes

$$p = \rho\,K\left(\frac{W}{k\rho}\right)^a$$

and, as above, we have

$$p_c = \rho_c\,K\left(\frac{W}{k\,\rho_c}\right)^a = \frac{1}{\rho_c^{a-1}}\cdot\frac{K}{k^a}\cdot W^a$$

$$p_t = \frac{1}{\rho_t^{a-1}}\cdot\frac{K}{k^a}\cdot W^a$$

and the percentage error is

$$\frac{p_t - p_c}{p_c} = \frac{\rho_c^{a-1} - \rho_t^{a-1}}{\rho_t^{a-1}}$$

If a has the value 2 as has been predicted, then the error here will also be about proportional to the temperature change, but the error is positive for ρ_t is less than ρ_c, and the error must be compensated for by

moving the low-pressure vent from the center. In either case the error will be about 0.02 per cent per deg. fahr.

The error introduced by change of viscosity can be predicted as follows: It can be shown that H is proportional to the kinetic energy of the vortical mass and we therefore have the relation

$$H = k\ (E - D)$$

where E is the kinetic energy, this mass would have if the liquid were nonviscous and D is the energy dissipated, changed to heat, as the water passes through the meter. The value of D can be shown to be proportional to μ, the coefficient of viscosity of the liquid. The relation between H and μ is therefore

$$H = A - B\mu$$

and H varies inversely as μ.

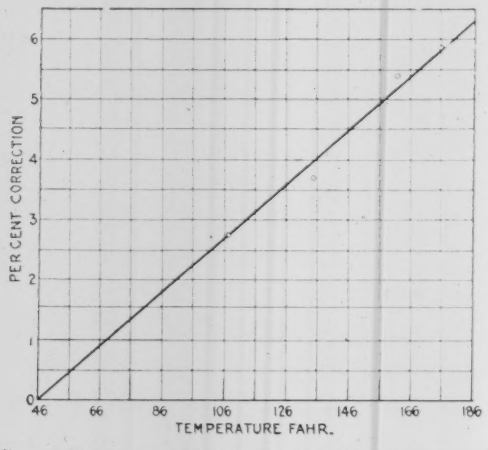


FIG. 5 CURVE INDICATING ERROR DUE TO TEMPERATURE CHANGE

The relation between the coefficient of viscosity and the temperature is nearly linear if the temperature does not approach too near to freezing, so in case of feedwater we may assume the linear relation. The error introduced by change of viscosity will be positive and must be compensated for by moving the low-pressure vent away from the center of the vortex. This error will amount to about 0.026 per cent per deg. fahr.

It results that the errors introduced by change of temperature nearly cancel one another if the meter is calibrated to give the flow in terms of volume, becoming —0.02 per cent+0.026 per cent, or 0.006 per cent per deg. fahr.; but if the flow is given in terms of weight, as is usually desired in feedwater measurements, the errors will add giving a resulting error of 0.046 per cent per deg. fahr. These expectations have been very nearly met in the operation of two models of somewhat different form.

EXPERIMENTAL RESULTS

Two models of the meter were constructed and tested in various ways.

This meter operates in accordance with the relation connecting the flow and the resulting difference in pressure between the surface and axis of a spiral vortex. The meter is fully as simple as the venturi or pitot forms and possesses several points of superiority. It consists of a cylindrical chamber terminating in a cone at one end and the other end capped, as shown in the accompanying diagram.

The fluid enters through a tangential inlet, thus giving a vortical motion to the contents of the chamber, and leaves through an axial outlet into which the cone terminates. The low-pressure tap is taken out through the center of the top cap and the high-pressure tap through the side of the chamber. It is to be noticed that the meter has no moveable parts and hence nothing to wear and get out of adjustment.

The calibration curve for this meter is much like that given by the venturi and pitot forms being

$$H = K\ .\ V^{a}$$

where a is a constant as is also K, and V and H are the velocity of flow and the meter head respectively. The value of K for the vortex form is about 4 times that for the pitot forms and 3 times that for the venturi meter having diameter ratio of 2:1. The value of the exponent, a, is 2.20, and for the venturi and pitot forms it is 2. This results in making the vortex meter sensitive and thus applicable to the measurement of low rates of flow such as is met with in feedwater conditions.

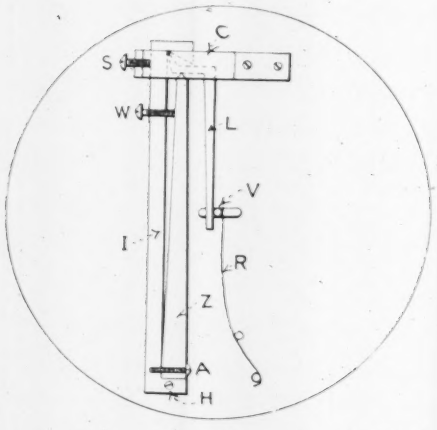


FIG. 6 TEMPERATURE COMPENSATING DEVICE

Four tests were made at different temperatures to determine the error for which the meter must be corrected. These results are given in Fig. 5. The meter was calibrated at temperature 46 deg. fahr. The percentage correction was determined in each case by dividing the actual flow, as given by weighing the discharge, into the difference between this and the value given by the meter. The curve has these values for the ordinates and temperature fahrenheit for abscissæ.

Here again we find a linear relation. The error introduced by changing temperature is proportional to the temperature change. The slope of the curve is 0.045 per cent. This is the percentage error introduced by changing the temperature 1 deg. fahr. Dividing this by the percentage variation caused by turning the thumbscrew once gives the number of turns required to correct the meter for a change of one degree temperature.

It results from this division that 0.0572 of a turn of the thumbscrew will correct for one degree change of temperature, and since the pitch of the thread is 0.025 in., the distance that the vent moves is 0.00143 in. This motion can easily be given by an unequal expansion arrangement and then the meter will give correct results at all temperatures. The design of this compensating device is shown in Fig. 6. The unequal expansion elements, *I* and *Z*, are made of invar steel and zinc respectively. The ratio of their coefficients of expansion is $\frac{8.7}{262}$. One end of the zinc element butts against a projection on the steel and is held in this position by means of the screw, *A*. Another screw *H*, fastens this end of the combination to the diaphragm. The movable arm *L*, passes across the free end of the zinc and pivots against an offset on the steel. The sensitiveness of the device can be varied by means of the set-screw *W*. The cap *C*, serves to hold the lever *L*, in position and also keeps the expansion elements pressed against the diaphragm. The expansion elements and lever can be rotated about the screw *H*, as a pivot by turning the set-screw *S*. This permits the adjusting of the lever *L*, against the vent-tube *V*. This tube is held firmly against the lever by the spring *R*. The whole expansion device is attached to the side of the diaphragm opposite to the vortex chamber, and since the diaphragm is made of brass which is a good heat conductor, the expansion elements take up the temperature of the water very quickly.

The meter, thus compensated, has been tested at various temperatures between 43 and 180 deg. fahr. and in no case was the error greater than 1.5 per cent, while the average error was below 1 per cent.

THE RECORDING DEVICE

The calibration curve for any rate-flow meter, except perhaps one with movable parts, is of the form

$$H = K \cdot V^{\alpha}$$

where *H* is the meter head, *V* the velocity of flow, and K and α constants. The value of α must be about 2 while the value of K depends on the type and geometric form of the meter. This parabolic relation between *H* and *V* makes it difficult to measure the lower values of *V*, and if the value of *H* is measured with an ordinary manometer gage, the percentage error in the measurement of *V* increases rapidly as *V* decreases.

Thus far three schemes have been employed for overcoming this weakness. In all three the pen, or pointer if the instrument is not self-recording, is moved by the operation of a float placed in one arm of the mercury manometer. According to one scheme the float operates a parabolic cam which in turn gives to the pen a motion proportional to the rate of flow. In the Lee recorder a displacement of the float causes a cylinder to rotate. The calibration curve of the meter is cut about the cylinder in a spiral-shaped groove. Through a roller contact the pen is made to follow the groove as the cylinder rotates thus giving a deflection proportional to the rate of flow. The third scheme employs a float of variable cross-section. The displacement of the float is opposed by a force

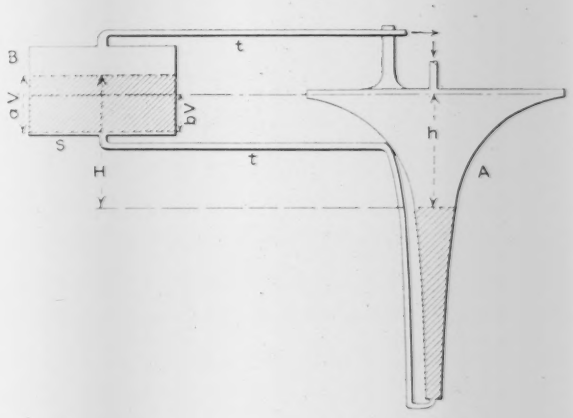


FIG. 7 DIAGRAM SHOWING PRINCIPLE OF RECORDING DEVICE

which is proportional to the displacement, and the shape of the float is such that its displacement as the mercury level changes, is proportional to the rate of flow.

In all three types the motion of the float has to be transferred to the apparatus outside through a rod which passes through a packing-box. The friction at this point is considerable and prevents the float from taking its true position. This difficulty is partly overcome by making the float large, but this requires a great amount of mercury and increases the cost of the apparatus. In all the cam types the error caused by pen friction is much greater for low than for high velocities for the ratio of pen to float motion is greater at low velocities.

The recorder to be described, the principle of which is shown in Fig. 7, is free from these defects. The apparatus is simply a manometer gage with one arm movable and the other one of variable cross-section. The high-pressure terminal of the meter attaches to the bell-shaped tube *A*, and the low-pressure terminal to the top of the movable arm *B*. The bottom of the two arms, *A* and *B*, are connected through the small tube *t*. Both the connections to arm *B* are made through flexible steel tubing and thus allows the arm

B to spring up and down. When the meter is in operation mercury is forced from A to B until the difference in level is equal to the meter head H, and if the shape of tube A is such that the quantity of mercury forced into B is proportional to the rate of flow through the meter, then the depression of the arm B, due to this weight will be proportional to V. This motion can easily be transferred to pen or pointer.

The form of tube A depends, of course, on the shape of the calibration curve of the meter and can be found as follows. Let this calibration curve be

$$H = K \cdot V^a \quad \ldots\ldots\ldots\ldots\ldots\ldots [1$$

and let h be the depression of mercury in tube A when a given velocity of flow V is taking place through the meter. Then if the cross-section of B is uniform and we assume that the weight of mercury forced into this arm is proportional to V, the depth of the mercury will also be proportional to V. Call this factor of proportionality a. At the same time the arm B has been depressed a distance proportional to V. Call this factor of proportionality b. Then the meter head H is related to these displacements as follows:

$$H = h + aV - bV = h + (a - b)\ V \quad \ldots\ldots\ldots [2]$$

The quantity of water that has passed the meter during any interval of time will be accurately given by the area underneath that portion of the rate curve corresponding to the interval in question providing the velocity has not, during this interval, fallen below 0.216 ft. per sec.

The quantity of mercury required is comparatively small, being about 200 cu. cm. The restoring force for a small displacement of the pen is great because all the displaced mercury tends to restore equilibrium and not the portion displaced by a float. Moreover, the friction of movable parts is reduced to practically that of pen friction.

DISCUSSION

F. ZUR NEDDEN referred to the loss of head caused by the meter. He thought that the dilatation of the lower part of the experimental meter, shown, was rather sudden and that if the venturi meter should be designed in the same way, with the dilatation as sudden as in this vortex chamber, probably the loss of head would be about the same as in the Hayes' meter. He suggested that the stretching out of the lower part and shaping it more toward the form of the diffusive part of the venturi meter, the result would be better.

Mr. Nedden pointed out that the author in his enumeration of devices for the recording of flow, had apparently overlooked one design which, is in a way, similar to his own. He referred to the design of the late Dr. Ansler of Schaffhausen in Switzerland which is known as a plano meter. This apparatus is very little known but one made by Dr. Ansler was tried out in Canada in connection with a venturi meter. It consists of two vessels which are connected by a U-shaped flexible tube, and filled with mercury, fixed to a weighing level. Mr. Nedden proceeded then to describe the device and he pointed out the features which render the recorder more sensitive as the zero rate of flow is approached, suggesting that the application of this principle might further intensify the accuracy of the vortex meter described by the author.

Mr. Nedden expressed doubt as to whether the Hayes' meter will in itself record accurately in the neighborhood of zero, as he had noted in checking the curves in the paper that in the vicinity of the zero point the meter does not seem to work exactly proportional to the rate of flow. He pointed out also a practical objection that may be encountered when the meter is arranged for practical use, namely, the question of sediment; he suggested that sediment is liable to accumulate in connection with boilers and that this would alter the real radius of the vortex chamber and thus permit a certain inaccuracy in the meter.

Mr. Nedden pointed out also that this form of meter is at a disadvantage in that it is considerably larger in diameter than a venturi tube for the same rate of flow. Also if to be used in connection with high pressure, it might be necessary to make this form of meter a great deal stronger than the venturi tube of the same rated capacity.

A. R. DODGE referred to a point of interest in connection with the formula of the calibration curve [1], which indicates that the loss of head varies as the square of the velocity in accordance with the same formula on other meters, the pitot tube meter and the venturi meter. He questioned if this is so, if the Hayes' meter is not of the same sensitiveness at low flows as the venturi meter or the pitot tube meter; that is, if the size of the instrument will not determine the constant.

Another point to which Mr. Dodge referred was the fact that the drop in pressure on a pitot tube meter is negligible, but that with the Hayes' meter the pressure drop is a considerable item.

CARL SMERLING asked if Mr. Hayes had attempted to measure gasoline with these meters. He pointed out the difficulty of the problem of measuring gasoline correctly in a meter and predicted a big field for a meter of this type if made available for gasoline.

THE AUTHOR, in answer to Mr. Nedden, pointed out the original meter, which is the first model he made, and suggested that it was more of the shape to which he referred. He admitted that there was much less loss of head in that model, but he stated that the reason he made the second form was to measure the loss of head which he could not measure on the first one; he did not get enough to measure. He said his desire had been to obtain enough loss of head to be able to measure it and also to get the stream lines coming out straight. He told how he had changed the form of meters since then including some changes in the neck, and that the loss of head had been materially reduced.

In reply to Mr. Dodge, he said that apparently the sensitiveness of the vortex meter is almost independent of the size of the chamber. While theoretically it would be absolutely independent, viscosity comes in and makes a little change, but that a large vortex chamber or a small one could be used and the constant would be almost the same. He replied to Mr. Smerling that the meter has been used for gasoline.

LABORATORY FOR INVESTIGATING AND TESTING LIQUID FLOW METERS OF LARGE CAPACITY

BY W. S. GIELE, PHILADELPHIA, PA.

Junior Member

The laboratory described in this paper was designed and built[1] to facilitate the testing and standardization of liquid flow meters of the V-notch weir and other types.

As made by the company at whose plant the testing laboratory was erected, the V-notch meter is combined with a feed water heater of the open type and is provided with an autographic recording and integrating device. A float resting upon the surface of the water in the approach chamber bears a vertical stem, actuating (by means of a cable and drum) a revolvable cam, adapted to displace a pen carriage or integrating train equal distances for equal increments in the rate of flow. The cam embodies the relation between the rate of flow and the head of water on the notch and the adaptation to different rates of flow is accomplished by varying the diameter of the drum upon which the cable winds and the angle of the notch itself, thus making it necessary to establish the relation between the coefficient of the notch and the angle.

The rate of flow through a flow meter may be computed by measuring, either gravimetrically or volumetrically, the quantities discharged during a known period. Such a method, however, involves starting and stopping errors, errors in maintaining the rate of flow constant for the whole period of test, in keeping a record of the exact variations of head or pressure, and in obtaining exact time readings on short runs.

To eliminate the errors involved in the above method, a continuous flow method of test was decided upon. A master flow meter was constructed and installed and so arranged that the rate of flow could be maintained accurately at any desired value for long periods. The performance of this standard was determined with all possible precision, after which it was used to measure the flow through the meters under test. A degree of accuracy could be secured, in the meters tested, practically equal to that of the standard. Also, the latter having once been accurately calibrated, disturbing influences arising from effect of proportions of channel of approach, conditions of surfaces, form and material of notch, directions and interference of currents of flow in the channel of approach, etc., could be ignored.

By the method used, not only is the accuracy of individual tests assured, but it is possible to conduct a very much larger number of tests and thus confirm the work done and take advantage of the law of averages.

[1] At the Harrison Safety Boiler Works, Philadelphia, Pa.

Abstract of paper and discussion presented at the Annual Meeting, December, 1914. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

DESCRIPTION OF APPARATUS

The testing plant has a large sump or storage tank from which the water is drawn and elevated to a constant head supply tank at the highest level, as shown in Figs. 1 and 2.

The purpose of the constant head tank is to supply water to a discharge orifice at a constant head so that the rate of flow through the standard notch may be maintained invariable at any desired capacity.

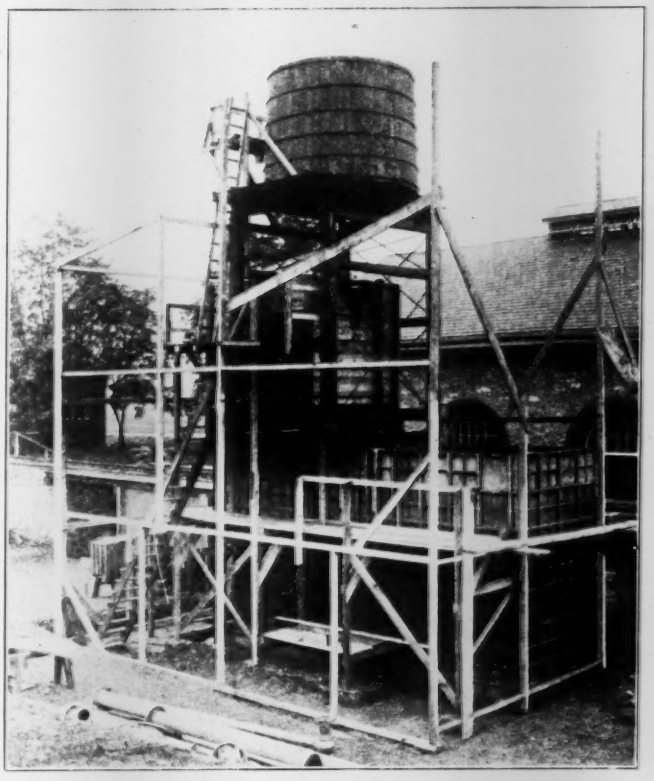


FIG. 1 METER TESTING PLANT

From the constant-head tank, the water passes to the standard-notch tank, thence over the calibrated standard notch into the meter under test, whence it is discharged to the storage tank to circulate again.

The two volumetric measuring tanks, shown in Fig. 2, were used in the preliminary work of calibrating the standard notch, and afterwards served as catch basins for the water discharged by the meters under test. The capacity of these tanks is approximately 525 cu. ft. each.

The entire plant was constructed with the utmost regard to permanency and rigidity. The foundation consists of a concrete slab carried to solid clay soil and reinforced in all directions by 1-in. rods.

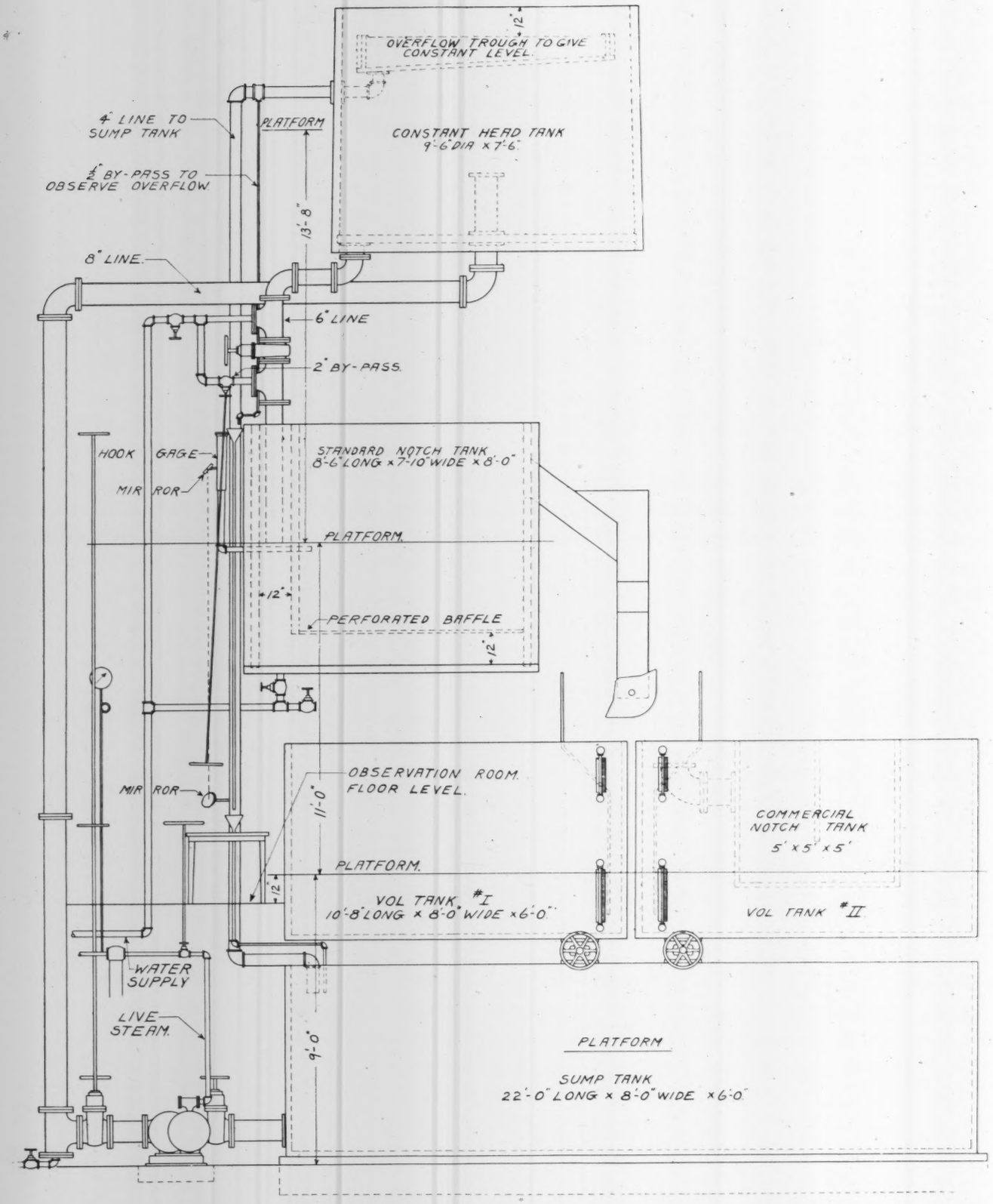


FIG. 2 DIAGRAM OF METER TESTING PLANT

The storage tank rests directly on the concrete foundation and holds a little over 1000 cu. ft. of water. The pump connection is located above the bottom of the tank to prevent sludge being drawn into the pump. The tank is supplied with a drain and washout, and with a system of steam pipes whereby the water may be heated to any desired temperature.

The pumping unit is an 7-in. DeLaval single-stage centrifugal pump. It is gear-driven by a single-stage DeLaval steam turbine, and its capacity is about 120 cu. ft. per minute against the head of the highest tank, which corresponds to a flow of about 450,000 lb. per hr.

The constant head tank is supported on a grill of structural steel carried by rigidly braced heavy columns resting on one of the volumetric measuring tanks. A constant head is maintained in this tank by means of an overflow weir at the surface of the water in the tank. This weir consists of a rectangular trough having inflow edges or weirs on both sides constructed of metal. An overflow is maintained over these edges throughout all experiments and is carried back to the storage tank, the line being provided with a bypass discharging into open funnels on both the standard notch level and the observation room level so that the observer may constantly watch the overflow. The approximate amount of water in the constant-head tank is indicated by a float to which is attached a chain passing over sheaves and extending to the pump room with pointers at each level.

The pipe line from the constant head tank to the standard notch tank contains a 6-in. valve for roughly setting the larger flows and a 2-in. by-pass valve carried around the larger valve for fine adjustment of flow.

The standard notch tank was rigidly constructed and is supported on columns carried outside the volumetric measuring and storage tanks directly to the foundations, the column loads being distributed on the foundation by two 15-in. I-beams grouted in. The tank is divided into two compartments by a rigid partition. The supply line discharges behind this partition 2 ft. below the surface of the water. The water spreads out over the bottom of the tank and rises through a perforated baffle, resulting in a quiet surface of approach for the standard notch.

The standard V-notch, Fig. 3, is approximately 22½-in. high by 11¼-in. wide at the top. Its full capacity at 18¼-in. head is roughly 110 cu. ft. per minute. Owing to the method of calibration, it was not necessary to find the apex or zero level of the notch with extreme precision, only to provide a reference point immovable with respect to the notch itself from which measurements could always be taken.

In order to detect any possible deflection of the standard notch tank due to the weight of water carried, four special gages are provided at each of the four corners of the tank. The geometrical center of the four positions was located and exactly symmetrical pipe connections were carried from each gage to a common opening at this center.

The level of the water flowing through the standard notch is obtained by means of a specially designed hook gage connecting with the still-water chamber. The unusual construction of this hook gage arises chiefly from the extreme range of height which it must cover and the consequent possibilities of error resulting from differences in temperature both between its various parts and between the water column within the gage tube and the water in the still-water chamber. To eliminate the former, the gage elements are so constructed that expansions due to increased temperature tend to compensate each other, and to eliminate the latter, the hook gage tube is jacketed by flowing water taken from the same source of supply as that to the still-water chamber. The hook gage is shown in Fig. 4.

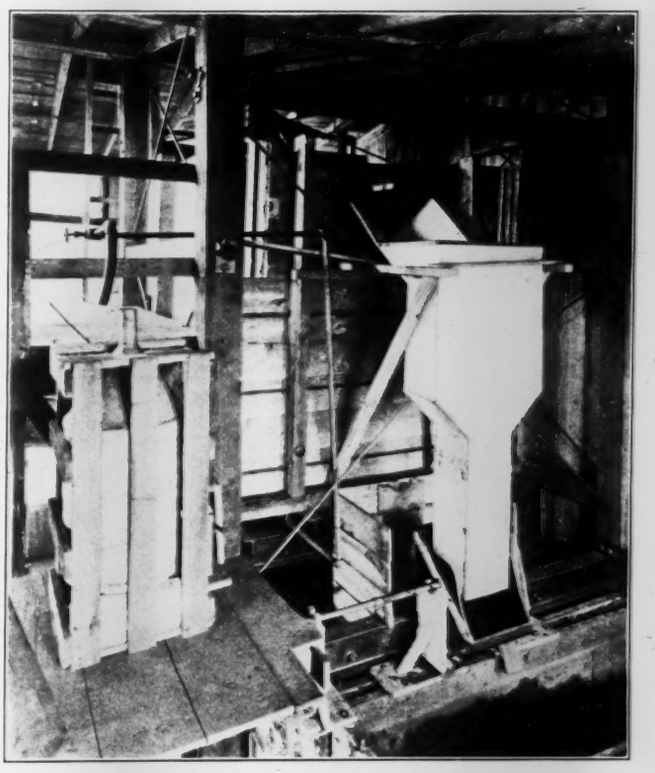


FIG. 3 STANDARD V-NOTCH USED IN TESTING PLANT

The hook gage system is aligned by gravity, and prevented from rotation by loosely fitting guides. The hook rod is suspended on a phosphor bronze cable which passes over a very accurate sheave running on a hardened axle. From the sheave the cable passes over a drum on the same shaft with the graduated wheel by means of which the settings are made and the readings taken. This wheel is 18 in. in diameter, and its circumference is graduated in units, each rep-

resenting 0.02 in. It has been entirely feasible with these graduations to estimate a movement of 0.0025 in. of the hook.

The register of the point of the hook with the surface of the water is observed from below the water surface, in which position it is possible to see both the hook itself and the reflected image on the surface of the water. The reading is taken through a magnifying lens and reflected downward and horizontally

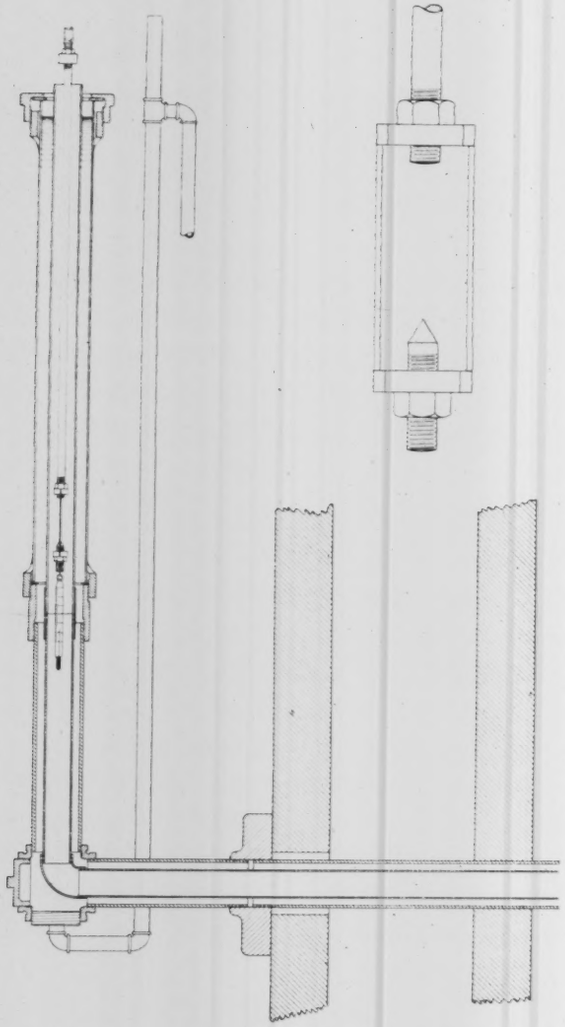


FIG. 4 DIAGRAM OF HOOK GAGE AND COLUMN

to the observation station, at which point a four-power binocular is rigidly supported for observation of the image. Optical distortion is eliminated owing to the reduction of illumination incident to this magnification. The hook itself is illuminated by means of a frosted incandescent bulb.

After passing the standard notch, the water is guided into a large funnel and conducted to a tipple by means of which it may be directed into either of the two volumetric measuring tanks, or into a meter under test. The tipple is arranged with electrical contacts to ring a gong when it is thrown over to facilitate the taking of time readings.

Owing to the number of readings to be taken and the amount of space covered by the plant, special means are necessary to bring all observations and controls to a central observation room. Fig. 5 shows this room and the desk from which observations are taken, as well as the binoculars and system of mirrors by which a magnified image of either the hook gages on the meter under test, or the hook gage on the standard-notch tank may be observed. It also shows the means for observing the level of the water in the constant-head tank, the overflow from the constant-head tank, the steam pressure in the steam line to the turbine and in the turbine nozzle chamber, from the operator's station: and how the steam throttle of pump, discharge valve and by-pass valve controlling the rate of flow from the constant-head tank to the standard-notch tank are all within the reach of the operator.

POSSIBLE ERRORS—TYPICAL TESTS

In the part of the paper which follows, an idea of the accuracy of the work is conveyed by assuming conditions very much worse than occur in operation and calculating the resultant error.

For instance, if the pump can be controlled only within a variation of discharge rate of, say, 166.8 cu. ft. per hour, and if the head of water over the overflow weir in the constant head tank is 0.2 in. (corresponding to an overflow of 7.26 cu. ft. per minute) an increase in the delivery rate of the pump of 166.8 cu. ft. per hour increases the overflow head to 0.245 in. This increased overflow would increase the head to the valves through which water is admitted to the standard notch tank (which is 10 ft.) from 10.0166 to 10.0204 ft., and the variation would be as the square roots of these two heads, or not more than 0.015 per cent.

The effects of error in the various elements of the hook gage are analyzed in the paper. While with the water jacket described, it was never possible to detect a difference in temperature between the water in the hook gage tube and in the still-water chamber exceeding ½ deg. fahr. during the course of a whole day, it is interesting to note the results which might be obtained from an unjacketed gage. Without the jacket water, it was found that a difference of 20 deg. fahr. (from 50 deg. to 70 deg.) was entirely possible and affected a vertical head of 30 in. of water. The reading of the gage under such conditions would be 0.048 in. in error. Fig. 6 shows the percentage error in flow due to error of 0.005 in. in hook gage reading.

The paper concludes with a description of the methods used in calibrating the apparatus and outlines the procedure in conducting a typical test.

The method of conducting typical meter tests in this laboratory is to set the meter into one of the volumetric measuring tanks so that it will receive its

supply from the standard notch and so that the volumetric measuring tank will catch its discharge simply as a catch basin and return it to the storage tank. The head of the standard notch, corresponding to the desired rate of flow for which is desired to find the head in the meter under test, is read from the larger scale curve and the hook gage on the standard-notch tank accordingly set. The flow through the system is then brought to the desired rate by controlling the water level in the standard-notch tank to the point of its hook gage. When conditions have become stable the head over the notch under test is read by means of its hook gage.

In running tests, it is necessary only to observe that the water level remains at the point of the gage on the standard notch and it is not necessary to read the height of the hook gage on the standard-notch tank during the progress of an experiment. The hook gage applied to the meter under test is provided with an extended shaft, bringing the graduated scale to the observation room where the operator can read the height of water passing over the weir under test. This reading is taken immediately above the eye pieces of the binoculars through which is observed the coincidence of the water surface and the hook.

DISCUSSION

H. E. EHLERS asked whether any experiments were made to determine how much variation existed in the surface of the water in the V-notch tank. He said the quantity flowing over the notch is determined by the hydraulic head back of the notch, and while it may be entirely possible to measure the level in the hook gage to an accuracy of 5/1000 in., he would like to know how nearly uniform the water level in the tank itself remained.

He referred to the assumed error of measurement of the head in the two large standardization tanks of 3/100 per cent at the higher rates of flow. The maximum flow is about 110 cu. ft. per minute, which allows about 5 minutes only for the filling of one of these large tanks. He asked how still the surface of the water in these tanks became. He said his own experience had been that water flowing into tanks under such conditions causes disturbances and pulsations which take a considerable time to die out. The surface may become smooth but it continues to rise and fall or pulsate.

Most of these meters, he said, are used for metering hot water, and the statement is made that the storage tank is provided with a system of steam pipes for heating the water to any desired temperature. A meter of this type measures volume, which is converted to weight by a direct coefficient. The weir is calibrated at 70 deg. or ordinary temperatures and a cam is worked out which is intended to give a rating in pounds. If the temperature of the water is raised to say 210 deg., its density is changed and so is the depth of immersion of the flow used to indicate the head of the weir. The first change is constant, but the second change is a variable and also has a much greater effect at low heads than it does at high heads. He asked how these weirs are calibrated for temperatures as high as 210 deg.

GEORGE H. GIBSON contributed a written discussion of which the following is a summary:

Two considerations favor the general adoption of the V-notch as a boiler feed meter. The first is its sensitiveness at small flows and the second its simplified construction made possible by assuming that the rate of flow is proportional to the 5/2 power of the head. This law is not strictly true even under ideal conditions, but its assumption facilitates the construction of float-actuated cams to move the recording pens.

FIG. 5 OBSERVATION ROOM

The numerous combinations of different notches with weir chambers of various dimensions required such a number of calibrations as to render volumetric and gravimetric methods tedious as well as expensive. To obviate this, the elaborate testing plant described was constructed and by its means the manufacture of V-notch meter chambers has been standardized.

In answer to Prof. Ehlers, Mr. Gibson said that the sensitiveness of these meters at small flows is not a matter of the operation of the notch itself. Overcoming the friction of the translating cam consumes such a large fraction of the power available for operating the recorder as to render impossible the measurement of differences in head at these flows to great accuracy. This is particularly true

in the case of the venturi meter in which reducing the flows to 1/4 reduces the velocity head to 1/16; below this flow great accuracy with this meter is out of the question.

J. H. MORRIS gave some personal experiences in a manufacturer's water meter testing plant regarding the difference in level in the filling tanks. The weir in this plant is flat-crested and is 8 ft. in width. When running at approximately a foot head, the differences of level in the weir chamber is not more than 2/100 ft. provided the stream is properly baffled as it enters the chamber. The constant head is obtained by a centrifugal pump driven by an electric motor, the differences in head being obtained by varying the speed of the motor. In a pressure chamber into which the pump delivers, the differences in head caused by the vibrations due to the action of the pump register from 1/10 ft. to 5/100 ft.

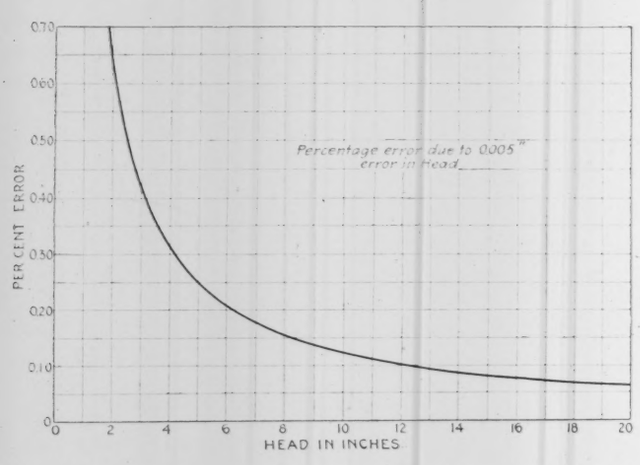


FIG. 6 CURVE SHOWING PERCENTAGE ERROR IN FLOW DUE TO ERROR OF 0.005 IN. IN HOOK GAGE READING

THE AUTHOR in replying to Prof. Ehlers said that the relative error at various heads due to the same error in reading the head, or what corresponds to the same thing, the error between float and cam, in various positions, is shown in Fig. 6. The correct method to compensate for this error is believed to be by measuring the force required to move the recorder and then to so proportion the water line area of the float that the latter will displace an amount of water proportional to this force. In this way it is possible to take full advantage of the greater relative accuracy of the V-notch at small rates of flow. Considerable trouble was experienced in getting the surface of the water in the standardization tank and in the volumetric tank quiet, but disturbances in these tanks are now controlled even with the rapid passage of water. Variations in the surface of the water in these tanks were shown by the gages in their corners.

He said that most of the other points raised by Prof. Ehlers had been covered by Mr. Gibson.

In a V-notch meter there are so many variables, each affecting the other, that it seems best when making commercial meters of this type to build each meter as nearly correct as possible, test it under its working conditions, and make the results of this test standard for that meter.

A NEW VOLUME REGULATOR FOR AIR COMPRESSORS

BY RAGNAR WIKANDER,[1] PITTSBURGH, PA.

Non-Member.

The variation in the consumption of compressed air being delivered by an air compressor necessitates some means of regulating the delivery in order to keep the receiver pressure as nearly constant as possible.

A number of regulators, governors or unloaders have been designed for this purpose and the object of this paper is to describe a new method serving the same purpose in a simple and efficient manner.

The existing volume regulators and their limitations and shortcomings which have led to the development of this new device are first reviewed, as follows:

A simple method for regulating the intake air is to vary the speed in proportion to the air consumption. For compressors driven by duplex or cross-compound steam ends this method is used to great advantage, the speed variation being, as a rule, obtained by means of a "speed and pressure governor," which acts upon a valve throttling the inlet steam. For compressors driven by single or tandem compound steam ends this method proves less advantageous, because the speed cannot be reduced below a certain value without excessive reduction of the flywheel effect.

A similar regulation between certain limits can be obtained by starting and stopping the compressor as soon as the air in the receiver pressure sinks below or rises above certain values. This method is suitable for small motor-driven compressors, but for larger motor-driven compressors it is, as a rule, not advantageous. In all cases, frequent startings of an air compressor under load are very hard on the transmission organs. In cases of belt-driven compressors, a belt shifter, automatically operated by air pressure, is sometimes used with a tight and loose pulley.

The choking intake unloader is in very common use. It consists of a choking valve placed in the suction pipe of the compressor and influenced by the receiver pressure. The advantages of this unloader are simplicity and gradual operation. Its disadvantages are waste of power, carbonization of the lubricant due to the great heat generated in the compressor cylinder when working on partial load, and the danger of explosion produced by such carbonization. If the unloader is arranged to open or close the intake entirely, the gradual unloading is sacrificed but the loss of power is avoided. The fact that this unloader is in common use, in spite of these great drawbacks, shows the need of a good and simple volume regulator.

[1] Hall Steam Pump Co., 918 St. James St.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

Regulation can be secured by variation of the cylinder clearance. This method is distinctly superior to the choking inlet method. In a well-known application, two clearance pockets are provided in each end of each cylinder, and automatically operated valves put one or more of these pockets in communication with the cylinder. The receiver pressure controls these various valves so as to regulate the volume of air pumped. The drawbacks of this system are high cost, extra space required, complication and limited number of efficient capacities of the compressor.

A fourth method of regulation is by keeping either the suction or the discharge valves open by force. If the former, some of the air drawn from the suction pipe during the suction stroke will return to it during the discharge stroke. If the latter, compressed air will enter the cylinder during the suction stroke and keep the suction valves closed, allowing no intake air to enter the cylinder. The first method is in common use all over the world, and it is possible to reduce the capacity of the compressor to one-half by keeping the suction valves at one end open by force all the time. The objections to this system are again high cost, complication of parts and the limited number of efficient capacities.

The best known type of unloaders on piston type compressors with positively moved valves operate to hold the suction valves completely open for a short time as soon as the air pressure exceeds the desired limit, and permit them to operate normally as soon as the pressure sinks. Several systems are, however, in use in which positively moved valves connect the cylinder with the suction pipe during a shorter or longer part of each discharge stroke. Both these systems operate satisfactorily and their only drawbacks are to be found in the high cost and rather complicated mechanisms required.

The object of the new regulator, which is called the Hall Volume Regulator, is to provide (in case of a piston-type air compressor with poppet valves) a simple, efficient and inexpensive means of varying the amount of intake air to correspond with the amount of compressed air being consumed.

The principle of the device is as follows: If the suction valve is held open by force after the suction stroke is completed, then on the discharge stroke a pressure is developed in the cylinder tending to overcome this force and close the valve. By a very gradual regulation of the force holding this valve open, its closing at an adjustable point of the discharge stroke is obtained.

The regulator is shown in Fig. 1. *A* is the compressor cylinder. *B* is the suction valve provided with a spring tending to close it. *C* is a piston, the action of pressure on which is to tend to hold the suction valve open. *D* is an auxiliary tank connected with the main receiver *F* through a port *G*, and with the atmosphere through the leak *E*. *H* is a pilot valve which closes the port *G* when the force exerted by an adjustable spring on the valve piston *I* overcomes the air pressure on its bottom. *J* is an adjustable needle valve which can be set to obtain a constant leak from the main to the auxiliary reservoir, thereby preventing the pressure in the latter from decreasing below a certain value.

When the compressor is working at a constant partial load, the pressure on the piston *C* is kept practically constant by admitting through the valve *H*

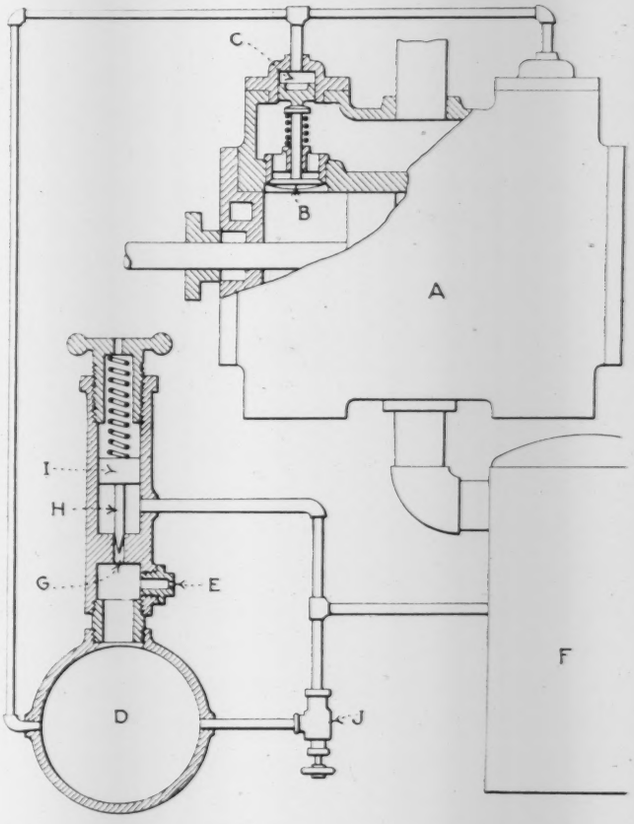


FIG. 1 APPLICATION OF REGULATOR TO AN ORDINARY POPPET VALVE AIR COMPRESSOR, SHOWING REGULATION BY ACTION ON THE SUCTION VALVES

into the tank *D* an amount of air equal to that escaping through the leak E. The suction valve then closes at such a point of the discharge stroke as to compress exactly the quantity of air consumed, the pressure in the main tank remaining constant.

An increase (or decrease) in the consumption of air will cause a slight momentary decrease (or increase) of the pressure in the main tank and of the quantity entering the auxiliary tank. This will decrease or increase the pressure in the auxiliary tank and change the cut-off of the suction valves so as to increase or decrease the amount of intake air until new conditions of equal supply and consumption are established.

The object of the valve *J* is to admit constantly so much air to the auxiliary tank as will cause the compressor to work at its maximum capacity for which a certain pressure in the auxiliary tank is necessary. If more air is admitted, the capacity of the compressor is reduced.

The same principle can be also applied to the regulation of the discharge valves of a piston inlet type of compressor, when it operates to close this valve at an adjustable point of the suction stroke. This application is described and illustrated in the paper, as is also a method of electrical control of the regulator.

It is claimed that the regulator can be applied with advantage to single or tandem compound steam driven compressors, being easily operated in connection with the ordinary speed and pressure governors. The device is also stated to be especially applicable to gas engine driven air compressors and to natural gas compressors in gas pumping plants where the pressure varies on account of field conditions. A chart is given, showing the comparative power consumption and quantity of free gas pumped per minute by a 17-in. cylinder compressor without and 20-in cylinder compressor with the Hall regulator.

The paper concludes with a number of indicator diagrams taken from a standard Hall poppet valve air compressor equipped with this regulator.

DISCUSSION

W. L. SAUNDERS, in a written discussion, stated that he regretted the author had given so little space to the system of clearance unloaders or controllers, which the writer claimed to be not only extremely simple and inexpensive, but had been demonstrated to be highly efficient.

He stated the cardinal requirements for the successful operation of a regulator for high speed compressors operating at constant speed are:

First, underload regulation must be obtained with such a degree of economy that the reduction in power required will be practically in a direct proportion to the reduction in output capacity.

Second, all mechanisms for regulating the compressor must be independent of the running gear of the compressor, otherwise the timing of the regulator as the regulation varies is difficult to accomplish, and the delicate yet durable mechanism required, operating at the full speed of the compressor continuously, is extremely difficult to design and manufacture. The difficulty and cost of maintenance and the shut-downs requisite for repair have proved excessive when the regulating mechanism is part of or dependent upon the running gear of the compressor.

Third, the regulator should be of such design that, when the compressor is called upon for average operation at partial load capacity, it can be so adjusted by hand as to limit the maximum capacity, and thus permit the compressor to operate at a higher average capacity or higher load factor than would otherwise be possible. This is a valuable feature under conditions where electric power service is furnished under a special maximum demand charge.

He stated that with the automatic clearance controller the inlet capacity of the compressor is reduced without reducing the intake pressure. On a two-stage compressor a constant ratio of compression throughout the entire load range, and the highest compression efficiency, is maintained throughout. The reduction in power secured with this method of control is practically in direct proportion to the reduction of load. The regulator is simple in construction and entirely automatic in operation.

On account of its under-load economy, the automatic clearance type is in his opinion of value in the majority of conditions of constant speed power-driven compressor service requiring under-load regulation.

JOSEPH ESHERICK wrote congratulating the author upon his excellent paper and for his work in developing the Hall volume regulator.

In regard to volume regulators, he said the author made no mention of the Richards Pressure Unloader. This unloader permits the compressor to run unloaded until the desired speed is obtained, when it loads the compressor automatically. The device is placed in the discharge line between the compressor and receiver and is simple and inexpensive. It is used primarily on motor-driven compressors. Another type, called the Initial and Pressure Unloader, has been designed for continuous running steam and electric-driven compressors. This embodies means of adjustment for any degree of regulation, from two to fifteen pounds.

One of the chief advantages of the Richards unloaders is that they permit, while the compressor is running unloaded, the passage of free air through the cylinder, with its resultant cooling effect on these parts.

PAUL DISERENS wrote that the author's objection to the choking unloader were well taken as directed against its application by gradual throttling, but that this application was practically obsolete. They were not well taken in the case of the total closure unloader, which is both safe and efficient when properly protected by atmospheric relief valves. The only drawback to the total closure unloader is the sudden change from full load to no load it causes, but where this is not objectionable at the electrical end the device answers very perfectly.

Theoretically the principle of varying the capacity of a compressor at constant speed by changing the clearance (clearance unloaders) is sound. The writer sees, however, the chief objection to the practical application of this principle for volume control in the obstruction to free communication between cylinder and clearance chambers occasioned by the restricted valve openings, of necessity interposed between cylinder and valve pockets.

The author's comment on unloaders on compressors with positively moved valves implies that unloaders operating the suction valves are the best type, whereas one of the most widely used devices of this nature involves an auxiliary bypass valve and connections.

The volume regulator which is the subject of the paper appears to depend on the gradual increase, during the entire length of the compression stroke, of the cylinder pressure as compared with the suction passage pressure, but it does not seem clear why such gradual increase should occur.

It would also appear that on compressors of medium and larger sizes, operating at the relatively high speeds now generally employed, a multiplicity of valves equipped with by-passing control would be needed. This would appear to present some difficulty in synchronizing their action.

The application of the regulator described to a two-stage compressor necessitates the use of two independent governors, one to regulate the line pressure and the other the intercooler pressure. Though this does not constitute a serious objection, it implies a complication to which the author takes exception in other forms of volume control.

JAMES TRIBE expressed his written opinion that the form of valve to which this regulator was shown applied might operate with fair success under low-speed conditions such as formerly obtained, but in modern compressors running at say 150 r.p.m. such a valve must have a very short life. Even the pressed steel cup valve, used for many years by the best builders on account of its lightness, was proving too massive to withstand the shock incident to valve action with high speeds.

An air compressor invented by Mr. G. H. Reynolds in 1876 and disclosed in U. S. Patent 187,906 embodied the principle of by-passing air from the cylinder to the external air on the compression stroke when the receiver pressure was increased above a certain limit. This invention, long since abandoned on account of the changing conditions of practice, was similar to the Hall regulator in that the receiver pressure controlled valves in the cylinder for unloading the compressor automatically.

Several large compressors recently built by the Allis-Chalmers Company have been equipped with unloaders embodying the Reynolds principle but reversed in application. These unloaders are independent of either the inlet or discharge valves and are not influenced by the speed of the machine.

JOHN GLASS[1] contributed a written discussion in which he said the Hall regulator would not apply to a pipe line as to a tank, as it is not practical to carry a constant discharge pressure at the various compressing stations of large gas-pumping plants. In such installations, the gas pressure is partly regulated at the compressing plant closest to the point of consumption, but the other plants back on the line are run at constant speed, that is, compressing all the gas possible. If more pressure is required in the line extra wells are turned in, and if the unloading device is affected by this, shortage of gas will occur at the consumption end.

He thought that this regulator was well adapted to gas engine driven compressors, especially in starting, and also on account of the limited capacity of the gas engine for overload, but that it was not of very great advantage in gas-pumping plants, as the changes in pressure are too great. When the field pressure drops the discharge drops also, giving about the same number of compressions. A large diameter compressor would be a disadvantage as the speed would have to be reduced so as not to exceed the economical number of compressions, about 4.5.

The facility with which the regulator could be applied he considered to be of importance.

[1] Chief Engineer, Carnegie Natural Gas Co., Pittsburgh, Pa.

FRANK RICHARDS said that the device described could only be used in connection with obsolete or obsolescent types of inlet and discharge valves. He said we have learned that poppet valves are by no means the best for air compressors. The poppet valve has considerable inertia, and moreover the resistance of a spring has to be overcome in opening it; oil gums its guides and the valve requires frequent examination and cleaning; it gives a more or less restricted and tortuous passage for the air, and this feature is accentuated when the air has to play back and forth for regulation purposes. With this valve, too, the pressure of the air within the cylinder is necessarily lower at the beginning of the compression stroke than that outside.

The Corliss inlet valve, wide open for nearly the entire stroke, and with large port area and a direct passage for the air into the cylinder, gives a freer inrush to the air and a fuller pressure at the beginning of the compression stroke.

The Rogler valve, which has replaced the poppet valve, annihilates its objectionable features without entailing others. This valve consists of a very thin steel plate covering concentric annular openings in the valve seat, and with a minute, free lift it gives the largest and freest passage for the air that has ever been realized. The Hall regulator cannot be applied to either this or the Corliss valve.

The regulation of a compressor should be accomplished without interference with its ordinary operation, and so it might be well that neither the inlet nor the discharge valves should be interfered with for this purpose. This may be secured by controlled changes of the cylinder clearance, an almost ideal mode of regulating the output from nothing to full delivery. It is possible mechanically to have an automatically pressure-adjusted changeable clearance for the air cylinder so large that at one extreme of its capacity a whole cylinderful of free air shall, when compressed up to receiver pressure, just fill this clearance space and none be expelled to the receiver. Then the compressor could run along continuously, and the air in the cylinder would be alternately compressed and re-expanded and no power expended.

A partial reduction of this clearance space would compel an expulsion or delivery of a portion of the air, and the remainder would re-expand upon the return stroke the same as with the clearance of full capacity, but in the latter case at the end of the stroke a portion of free air would be taken in sufficient to replace the volume delivered, and so on. With this adjustable clearance reduced to its minimum, the cylinder would be delivering its full charge of air, and its action would be entirely normal.

Such a clearance control is not yet fully realized, but the four stage clearance controller already in extensive use gives highly satisfactory results in practice. The only expense it involves is its initial cost, as it requires no constant operating expense.

THE AUTHOR, in his closure, said that although Mr. Richards referred to poppet valves as being obsolete or obsolescent, he was of the opinion that almost 90 per cent of the compressors used in this country were fitted with this type of valve.

In reply to Mr. Glass, who stated that a volume regulator operating with constant pressure was not needed in large gas pumping plants, the regulator described is not limited to constant pressure, as it can also be operated to give any constant volume desired. In the ordinary practice, a gas engine driven compressor is built so small that the engine can pull it under any conditions. With the regulator described, the gas engine can be built just large enough to take care of the ordinary conditions, and the amount of intake gas so regulated that the work required for its compression corresponds to the capacity of the gas engine.

In reference to the criticism by Mr. Tribe of the novelty of this regulator, the author stated that investigation had established the existence of only one prior invention of similar character. This was the subject of a patent to Mr. E. A. Rix in 1900 (U. S. Patent No. 602,170), in which a positively moved system of levers, similar to the Corliss valve gear, operated to close the inlet valves of a compressor at some point of the compression stroke varying with and dependent upon the pressure in the outlet pipe or its connection.

DAMAGES FOR LOSS OF WATER POWER

BY F. W. DEAN, BOSTON, MASS.

Member of the Society

When the water of a stream is diverted at any point, damages for loss of power must usually be paid to any mills having a water power plant located below the point. Cases are frequently heard before a commission, occupy much time, involve considerable expense, and the testimony is widely divergent. Some of the questions about which such testimony differs are discussed in this paper under the heads: Determination of value of water power, rate of capitalization, proper development of water power, method of estimating average yields, proper auxiliary engine to install, kind of coal, economy of steam plants, use of existing engines and boilers to supply loss by diversion, efficiency of water wheels, friction of water wheel gears and shafts, developed and undeveloped powers, and value of water for non-power purposes.

It is now generally understood that the determination of the value of water power takes into consideration the cost of making power by steam which may be spoken of as the standard for comparison. This value is the capitalization of the annual saving by the use of water power. The mill can be operated by the water power combined with a proper steam plant to produce uniform power throughout the year, or by the best adapted steam plant. The costs may be tabulated in a general way as in Table 1. If the amount

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

TABLE 1 GENERAL COSTS OF POWER BY STEAM AND BY WATER

Annual Costs of Power by a Steam Plant	Annual Costs of Power by Water Combined with Steam Sufficient for a Uniform Power	
	Water Power Plant	Auxiliary Steam Plant
Interest	Interest	Interest
Depreciation	Depreciation	Depreciation
Insurance	Insurance	Insurance
Taxes	Taxes	Taxes
Attendance	Attendance	Attendance
Fuel		Fuel
Supplies	Supplies	Supplies

of the first column exceeds that of the sum of the second and third, the water power has value.

The theory in a water power damage case is that the award shall be such that the interest thereof shall be sufficient to equal fully the extra expense caused by the diversion. This rate is usually taken at 5 per cent, but is a subject of argument.

In the case of an undeveloped power a higher rate of capitalization may be used as a means of scaling down the value and as representing the necessary profit of an enterprise.

Water powers are seldom developed to the power of the wet months, but to the average power of the eighth or ninth month when the stream flows are arranged in the order of wetness.

A water power produced by the unassisted natural flow of the stream is of very little value when developed to the customary extent since the largest yield in a given period is often many times the smallest yield (Table 2).

TABLE 2 AVERAGE YIELD OF WATER SHED

Months in Order of Wetness	Yields in Cubic Feet per Second per Sq. Mi. of Watershed		
	Sudbury River, Average of 37 Years	Nashua River, Average of 15 Years	Little Westfield River, Average of 6 Years
1	2	3	4
Dryest	0.137	0.330	0.22
2nd dryest	0.232	0.492	0.37
3rd dryest	0.386	0.633	0.47
4th dryest	0.546	0.802	0.81
5th dryest	0.707	0.939	1.00
6th dryest	0.929	1.106	1.37
7th dryest	1.156	1.319	1.64
8th dryest	1.574	1.718	2.59
9th dryest	2.188	2.283	3.24
10th dryest	2.746	2.764	4.32
11th dryest	3.518	3.542	5.42
Wettest	4.776	4.654	7.21

Areas are frequently available in the watersheds that can be dammed and overflowed in the wet months. This is a saving feature of water power development of great importance, but probably in no case results in a uniform power. Table 3 shows the results for the average and dryest years in a case investigated by the author. Even in the smallest development, a steam plant is necessary.

In treating a water power problem, a systematic arrangement of the yields of the stream is necessary and the most convenient and effective one is that of monthly yields in the order of wetness or dryness. The calendar order is without significance.

Investigation shows that the most economical engine to install depends upon the power to be made up to produce a steady power. Between certain limits, the most economical engine is the simple non-condensing

TABLE 3 RESULTS FOR AVERAGE AND DRYEST YEARS

Month	Horsepowers Based on the Natural Flow of the River		Horsepowers of 5000 h.p. Development Using Storage		Horsepowers of 7500 h.p. Development Using Storage		Horsepowers of 10,000 h.p. Development Using Storage	
	A	*B*	*A*	*B*	*A*	*B*	*A*	*B*
Dryest	1340	130	4400	130	1340	130	1340	130
2nd	2250	909	5000	909	2250	909	2250	909
3rd	3850	1904	5000	1904	3850	1904	3850	1904
4th	4590	2247	5000	4623	7500	2247	4590	2247
5th	5100	2465	5000	5000	7500	2465	5100	2465
6th	6000	2983	5000	5000	7500	5275	9900	2983
7th	7200	4455	5000	5000	7500	7500	10000	4455
8th	9350	5364	5000	5000	7500	7500	10000	8879
9th	11200	7699	5000	5000	7500	7500	10000	10000
10th	13500	9127	5000	5000	7500	7500	10000	10000
11th	16800	9213	5000	5000	7500	7500	10000	10000
Wettest	27700	20457	5000	5000	7500	7500	10000	10000

A = Results for the average year.
B = Results for the dryest year.

type. Simple condensing engines, compound condensing engines, condensing or non-condensing steam turbines, may be best. The greatest net economy as made up of fixed charges and costs of operation must be considered.

The make-up steam powers vary between wide limits, and judgment must be exercised as to the best type of engine to install and also its size.

The kind of coal considered in any case should be the normal coal of district. This is nearly always a bituminous coal, although the coal actually used is often a mixture of bituminous and fine anthracite.

In damage cases a great deal of testimony is given concerning the economy of steam plants. It is well known that the economies of such plants are very variable and differ from each other. In some cases great care is taken to have good plants carefully operated, while in others they are neglected and incompetent men are employed, but such plants as the latter should not be taken as criterion for basing an award for damages.

Engines and turbines may be non-condensing or condensing, simple or compound. Steam engines high in economy are being devised. Superheated steam is being introduced and may be at any time installed in mills that are damaged by loss of water. Using better condensing apparatus is resulting in improved economy. The simple non-condensing engine, the exhaust steam of which is utilized for mill processes, forms the most economical steam plant, and this is generally understood. These considerations bear upon the testimony that may be given in cases such as are under consideration.

Another feature of damage cases is that of allowing for the variable loads that auxiliary engines carry, but recent engines are not as wasteful with such loads as were engines made 20 years ago. However this may be, there is considerable uncertainty in estimates of the coal used with variable loads.

It is beneficial if in damage cases the power to be made up month by month is sufficiently small to be assumed by the existing engine in the plant. The main engine is likely to be of an economical type for the work and would in every way be more satisfactory to the damaged party by itself than in connection with an additional engine. If an additional engine is put in, the award will be larger, but the recipient will have a more expensive plant. If the existing engine cannot carry the additional load, another should be added, which is usually done if the highest award is sought.

In many cases, too, the existing boiler plant and force of firemen is ample to carry the additional load. It is better if this is so, but if not, the award should contemplate an addition.

The maximum efficiency of new and clean waterwheels has been found to be nearly 85 per cent. Testimony is often given to the effect that the average efficiency of waterwheels is as much as 80 per cent, and this is used in estimating the power lost, while an examination of efficiency curves, and contemplation of conditions to which wheels are subject, show that such an efficiency under the conditions is impossible. In the author's opinion the average efficiency used in water power damage cases should be taken at not more than 75 per cent.

The power of vertical water wheels is transmitted through bevel gears, the friction of which has been shown to be from 3 to 4 per cent. The shaft of a horizontal waterwheel, and the horizontal shaft driven through the gears of a vertical wheel, correspond with the shaft of an engine, enabling powers to be compared. The delivered power from horizontal shafts for wheels and engines, compared with the steam power is:

Gross water power, per cent	100
Average power delivered by shaft of horizontal wheel, per cent	75
Average power delivered by horizontal shaft of vertical wheel, per cent	72
I.h.p. of steam engine, per cent	100
Average power delivered by engine shaft, per cent	92

In the case of a developed power the problem of determining a proper award is comparatively definite. In the case of an undeveloped power, supposititious cases have to be assumed, and the award is a guess.

A knowledge of the costs of undeveloped powers is, of course, very valuable, but such information is difficult to obtain.

The determination of the value of water for non-power purposes does not usually come from the diversion of water, for when this occurs it is common to give a manufacturer as much water as he needs for such purposes, as for boilers, paper washing, dye houses, etc. Sometimes the question arises as to how much shall be paid to the owner of a source of supply for a quantity of water, or how the price shall be readjusted.

DISCUSSION

JAY M. WHITHAM, in a written discussion, expressed the opinion that the range of efficiency of variable loads which have to be allowed for in damage cases, is greater than the author appears to think.

As regards the use of existing engines and boilers to supply power lost by diversion, he thinks that the market value alone must control, and also that the condemning party should pay its pro rata of operating costs in the mill. He emphasizes particularly that in all condemnation of water powers, local considerations must control, and the loss in market value must determine the result.

PHYSICAL LAWS OF METHANE GAS

BY P. F. WALKER, LAWRENCE, KANSAS

Member of the Society

In the recent marked development of the natural gas industry in the Middle West, there has been a realization of the necessity of a greater degree of accuracy in the many technical problems which have arisen.

The compression at various points in the transmission line in order to maintain pressures giving economy in transmission, the determination of conditions of flow by line-flow formulae and the measurement of the gas purchased and sold, involve an exact knowledge of the characteristics and behavior of gas under varying pressures. Methods of dealing with these problems have been the subject of various recent articles in The Journal, and through this and other channels much has been done towards systematizing the work and establishing formulae for convenient calculation.

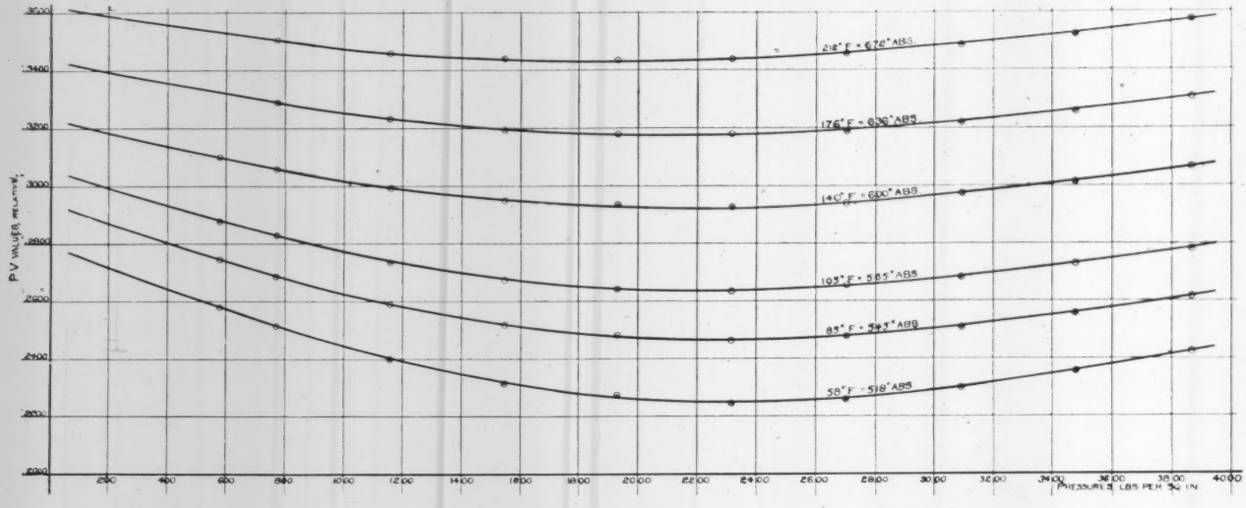


FIG. 1 *PV*-VALUES; *T*-CONSTANT CURVES ON PRESSURE, ORIGINAL DATA. VOLUMES OCCUR IN RELATIVE VALUES ONLY

In all the published matter available, calculations have been based on the laws of perfect gases. The laws of Boyle and Gay Lussac have been assumed to hold for the gas being transmitted and measured, but it is well known that this is not true.

The present paper attempts to develop a few equations which relate quantities of real significance and to establish values of some coefficients which may be applicable where a very high degree of accuracy is demanded.

The error involved in the use of the perfect gas

Abstract of paper and discussion presented at the Annual Meeting, December, 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to non-members.

laws is most pronounced in line-flow formulae and in measurement of volume. It is necessary to convert high pressure volumes to equivalent volumes under pressure at or near atmosphere. Density is always determined under atmospheric pressure, or slightly above, and it is then assumed that under widely varying pressures this factor will vary in a fixed proportion to the density of air under widely varying pressure. Since air contains saturated vapors which do not conform to the laws of perfect gases, serious errors may be involved in this assumption, entailing financial loss to handling companies. In many other calculations, the equation expressing the relationship between pressure and volume during the adiabatic change of state becomes of great importance. In the characteristic equation, $PV^n = \text{constant}$, the usual value taken for n is 1.26. It is to be expected that the true value is different from this, which is of considerable significance since V is comparatively large. The variations from the laws of perfect gases in the case of changing temperature are developed in the paper as a step in the process of investigation, although not commercially important.

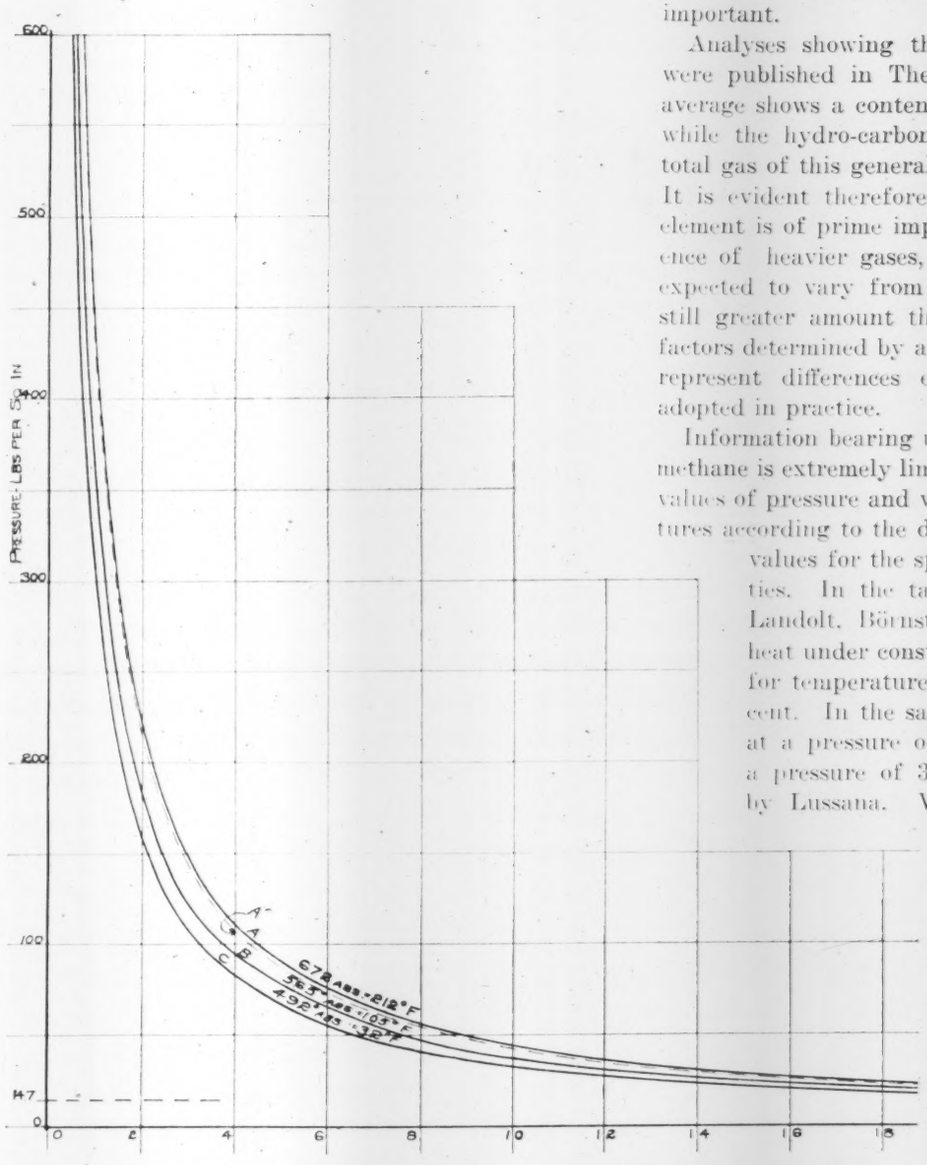


FIG. 2 *T*-CONSTANT CURVES FOR 1 LB. OF GAS. CURVE *A'* IS A PERFECT GAS ISOTHERMAL. VOLUMES OCCUR IN TRUE SCALE

Analyses showing the composition of natural gas were published in The Journal in May, 1912. The average shows a content of over 80 per cent methane, while the hydro-carbons closely associated bring the total gas of this general character to over 90 per cent. It is evident therefore that a study of this leading element is of prime importance. Because of the presence of heavier gases, however, natural gas is to be expected to vary from the laws of perfect gas by a still greater amount than does methane, so that the factors determined by an analytical study of the latter represent differences even smaller than should be adopted in practice.

Information bearing upon the physical properties of methane is extremely limited. All that was found were values of pressure and volume under varying temperatures according to the determinations by Amagat, and values for the specific heat by various authorities. In the tables of physical constants by Landolt, Börnstein and Meyerhoffer, specific heat under constant pressure is given as 0.5929 for temperatures varying from 18 to 208 deg. cent. In the same reference, values of 0.5915 at a pressure of 1 atmosphere and 0.6916 at a pressure of 30 atmospheres are authorized by Lussana. With other physical chemists, the above authorities assign an average value of 1.1315 for the ratio of specific heats at constant pressure and constant volume. The value used here is 1.235 to 1.24. This is given by Mr. Kent. In an appendix the effect of varying temperatures on this value is considered. Another value commonly used by gas men (and in the paper, above referred to in The Journal, May, 1912) is 1.266.

Fig. 1 is a graphical representation of the PV values for methane (Landolt, Börnstein, Meyerhoffer, Amagat). This shows an appreciable variation from the perfect gas, for which the PV curve would follow a horizontal line.

The specific heat values for constant pressure and constant volume are both expressed in the form $(a + bt)$, the quantity a differing by a fixed amount

for the two cases. It is probable that the values thus given are slightly in error because of this constant difference which represents the work done during a constant pressure change accompanying one degree change in temperature, and the change of volume for such a constant pressure change would be represented by a curve rather than by a straight line. The error involved is, however, extremely small. It should be said, that the uncertainty as to the values of specific heat is a matter of far greater importance in the actual handling of natural gas than it is in connection with a discussion of pure methane. Natural gas carries many other elements, these often being actual particles of liquid, and any attempt to use measuring devices which involve a knowledge of specific heat value is subject to serious and uncertain error.

In the form in which the data for values of PV occur, the volumes are given on a relative basis, making it necessary to deduce the values of PV at standard atmospheric pressure and at 32 deg. fahr. in order to determine the mass of the gas dealt with and make it possible to express values on the basis of unit weight. In carrying this out, a difficulty was encountered because the values given are for high pressures only. This made it necessary to extend the curves in Fig. 1 outside the limits of observation values which could be done with fair safety to a point where values for the pressure of 150 lb. are measured. Curves for constant pressure are given in the paper establishing a set of values at 32 deg. fahr.

With this set of values of PV for pressures of 150 lb. to 2,000 lb., a single constant temperature curve was drawn on an enlarged scale, and the curve was extended to the standard pressure of 14.7 lb. per sq. in. Since the density of methane at this pressure and temperature is well established at 0.04464 lb. per cu. ft., the PV value of 2690 gives 0.05674 lb. of gas for the weight. Knowledge of this weight now made it possible to express the volumes in absolute units. While it is true that the extension of curves outside of the observed values on these preliminary diagrams is subject to some error, the curves thus extended are of very slight curvature and are of a character well established.

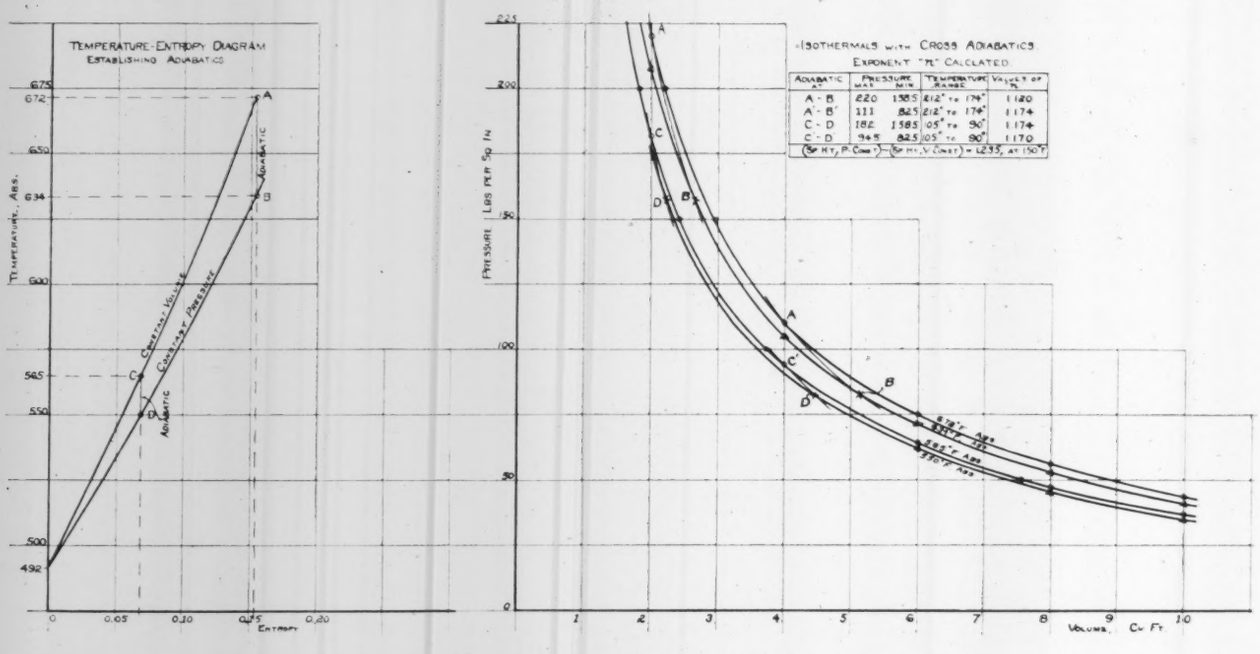


FIG. 3 DERIVATION OF ADIABATICS. ALL VALUES FOR 1 LB. OF GAS

The isothermal curves in Fig. 2 were next laid off. A and B are at the original temperatures of observation. C is established by the extension of curves in previous diagrams. Comparison of curve A with an equilateral hyperbola A^1 drawn from the point of highest pressure on the curve shows that there is a noticeable variation. The gas fails to conform to Boyle's law by a significant amount when a considerable range of pressure is involved. A calculation of the equivalent volume at atmospheric pressure for a quantity of gas flowing in a line under 300 lb. absolute pressure, if made in accordance with Boyle's law, produces an error of 4 per cent. This is an item of considerable significance when large quantities of gas are being handled. These isothermal curves give a value of n of approximately 0.99.

Equations connecting temperature and pressure at constant pressure have been found to be as follows:

EQUATION FOR CONSTANT PRESSURE	EQUATION FOR CONSTANT VOLUME
$P = 50$ lb., $T = 75.4\ V$	$V = 2$, $T = 2.87\ P+40$
$P = 100$ lb., $T = 152.5\ V$	$V = 4$, $T = 6.51\ P-50$
$P = 200$ lb., $T = 280\ V+50$	$V = 6$, $T = 8.80\ P$
$P = 300$ lb., $T = 427\ V+50$	$V = 8$, $T = 12.0\ P$
$P = 400$ lb., $T = 539\ V+80$	$V = 10$, $T = 15.2\ P$
$P = 500$ lb., $T = 584\ V+150$	

Values of n in the equation representing an adiabatic expansion found by the temperature entropy method are given in Fig. 3. These values are seen to be about 1.17, or very markedly below the ratio of specific heats. In much of the work in which this quantity enters it is in the form of $\frac{n-1}{n}$. When $n = 1.17$, this expression is equal to 0.145, while when $n = 1.235$, the expression equals 0.19. A value of n of 1.266, commonly employed in natural gas calculations, gives the value of 0.21 for the expression. From this it is seen that in the form in which this quantity enters into much of the engineering work, the use of specific heat ratios involves an error of 30 to 50 per cent.

The paper points out the necessity for more extended work upon the specific heat and other direct factors of methane and other hydrocarbon gases to render possible tabulations of correction factors for modifying results, obtained by Boyle's and Gay Lussac's laws, for application to commercial natural gas.

Three appendices are given, two explaining the calculations used in deriving the various curves and one considering specific heat and calculation of entropy.

DISCUSSION

CARL SMERLING called attention to an interesting point in connection with the heavier ends to the deposit in the pipe lines. He had been at work on a proposition of using those ends for the liquifying of gas, for gas production in town plants through the middle west and referred to one at Sibley, Ia., which uses liquified gas at a Bonnet gravity of 86 per cent. His company had made a special distilling process for this gasoline which was a casing head or common gas process. In distilling this product, they have been able to reduce the precipitate or residue on a cold process to approximately 8 per cent., where with the old process of using casing head gasoline at 86 Bonnet, there would have been a residue of possibly 30 per cent; the latter would necessitate the emptying of the drip tanks weekly, whereas with the new process it had not been done inside of four months. He mentioned another plant in Pleasantville, Ia., where a similar plant has been used. The Sibley plant is a pipe line system of about ten miles.

THE AUTHOR, in replying, said that the troubles from condensation referred to are not very serious so far as transmission is concerned. He stated that in the transmission of natural gas by compressors, it is not at all uncommon to have the liquid of condensation dripping out. By this it is not meant that methane gas changes to gasoline, but other gases, most of them of the paraffine group, which are present in the natural gas, will liquify under certain conditions. He stated that certain chemical changes are going on continually, having found in laboratory work that the chemical values are changing back and forth, either under heat treatment or under the varying pressure treatment.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

In addition to articles which can be conveniently abstracted there appear from time to time important investigations either too extensive to be used with the space available or embodying extensive tables, the reproduction of which would usually take so much space as to exclude other matter of interest. Since, however, some of these tables present matter of great interest which may be of important value to engineers in that particular line of work, an attempt will be made to present them in the form of engineering data similar to what is done in the standard engineering handbooks. In an early issue, one page will be devoted to such engineering data.

THIS MONTH'S ARTICLES

The first article describes a portable air compressor and dynamo plant, interesting because of its compactness and good design. In the same section are described governing devices used on Swiss turbo blowers, both for constant output and constant pressure, as well as a device the purpose of which is to prevent "pumping." In the previous issue of the Journal was described a Blezinger gas producer. In this issue further data on its construction are reported and tests described. The main interest of this type of producer lies in the fact that it permits the gasification of lignites high in moisture.

An article by Stribeck is abstracted showing that the law of similarity does not generally apply to phenomena occurring in notch shock tests and that it is limited by the influences due to the crystalline structure of the metal. In the steam engineering section are described devices for removing ashes and slags from a grate by suction, without permitting dust and hot gases to escape into the outside atmosphere. Further is abstracted a report of tests carried out in the experimental laboratory of the Bavarian Association for Boiler Inspection, having for their purpose to establish the relation between load on boiler and wetness of steam in the case of a Cornish boiler where it is shown that water tube boilers produce steam of greater moisture than a tubular boiler and the percentage of moisture in the latter is less than in the former. Several new types of grates are described, among them the inclined grates with compound grate bars and an improved type of hollow grate bar.

Two papers on coal dust fired reverberatory furnaces were presented before the American Institute of Mining Engineers. Before the same Society was presented a paper describing experiments on the flow of a mixture of sand and water through spigots, giving data on the relation between composition and viscosity of such mixtures. Among other things, the paper gives a definition of the term "viscosity" as applied in the case of such mixtures where not the actual viscosity of the liquid is affected but the volume rate of flow of such a mixture through an orifice.

From an advance paper of the Institution of Mechanical Engineers is abstracted a discussion on the standardization of pipe flanges and flanged fittings, containing among other things data of an investigation as to the stresses on the flange, which the author proves to be of two kinds.

The pre-cooling of Canadian fruits and the general subject of fruit handling is discussed in a paper before the Ontario Fruit Growers' Association, where also are quoted some interesting results and a cold storage laboratory connected with a pre-cooling plant in Ontario, Canada.

The subject of forged and rolled steel pistons on locomotives is treated by W. W. Scott, Jr., in a paper before the Railway Club of Pittsburgh. The author takes up the matter from the point of view of locomotive balancing and gives some interesting data on the present tracks on the Pennsylvania lines, especially, and then proceeds to the description of a new method of manufacturing locomotive pistons, developed at the Homestead car wheel works of the Carnegie Steel Company.

Several papers are abstracted from the Journal of Mechanical Engineers, Tokio, Japan, such as the distribution of stress in a tension strap having a circular hole filled with a plug; the theory of elasticity of rods whose center line is a space curve and a paper on the transversal strength of wire guns.

From an extensive paper on the Coon Rapids hydro-electric development on the Mississippi River near Minneapolis by J. W. Links (Western Society of Engineers) data on some features of construction of interest to the mechanical engineer are reported.

FOREIGN REVIEW

Air Machinery

PORTABLE AIR COMPRESSOR AND DYNAMO PLANT

The article is devoted to the description of the Kaiser Wilhelm bridge in Fürstenwald and among other things it describes a portable dynamo and compressor installation used in the construction of that bridge. Only the latter is abstracted here.

The portable dynamo and compressor plant shown in Fig. 1 consists of a 30 h. p. benzole engine *a* with two hand feed pumps, for benzole and water. The compressor *b* of 2.2 cbm. (77.68 cu. ft.) capacity with manometer, automatic cut-off, return cooling plant, water tank *c*, air tank *d*, 16 kw., direct current dynamo *e* working at 250 volts, and transmission pump *f*. All this is located on a powerfully built truck and weighs approximately 12 tons. It carries a main frame which both carries the load and serves as a water tank. This frame carries the benzole engine, compressor and dynamo. The dynamo and compressor are driven by the engine while the cooling water pump of the compressor is driven from the compressor itself. The hot water from the compressor is led to the roof of the car, distributed there and cooled, after which it returns to the water tank and continues the same circulation. The benzole engine circulating water is cooled by evaporation.

The entire plant may be carried or loaded in a car in a single unit and can be brought direct to the work for

which it is wanted. As soon as the proper tanks are filled with water and fuel, it is ready for operation. The engine is automatically regulated by the throttling of the fuel supply. The fuel consumption is approximately 300 grams (0.66 lb.) per h. p.-hr. and cooling water lost through exaporation is approximately 26 gal. per working day of 10 hr. (*Die Kaiser-Wilhelm Brücke in Fürstenwalde a. d. Spree*, Karl Bernhard, *Zeits. des Vereines deutscher Ingenieure*, vol. 59, No. 3, p. 51, January 16, 1915, serial article, not finished, *d*).

Turbo-Blower Governing Devices

The article describes steam turbines and turbo blowers exhibited at the Swiss National Exposition in Bern in 1914 by Brown, Boveri and Company. Only the part referring to regulating devices is here abstracted.

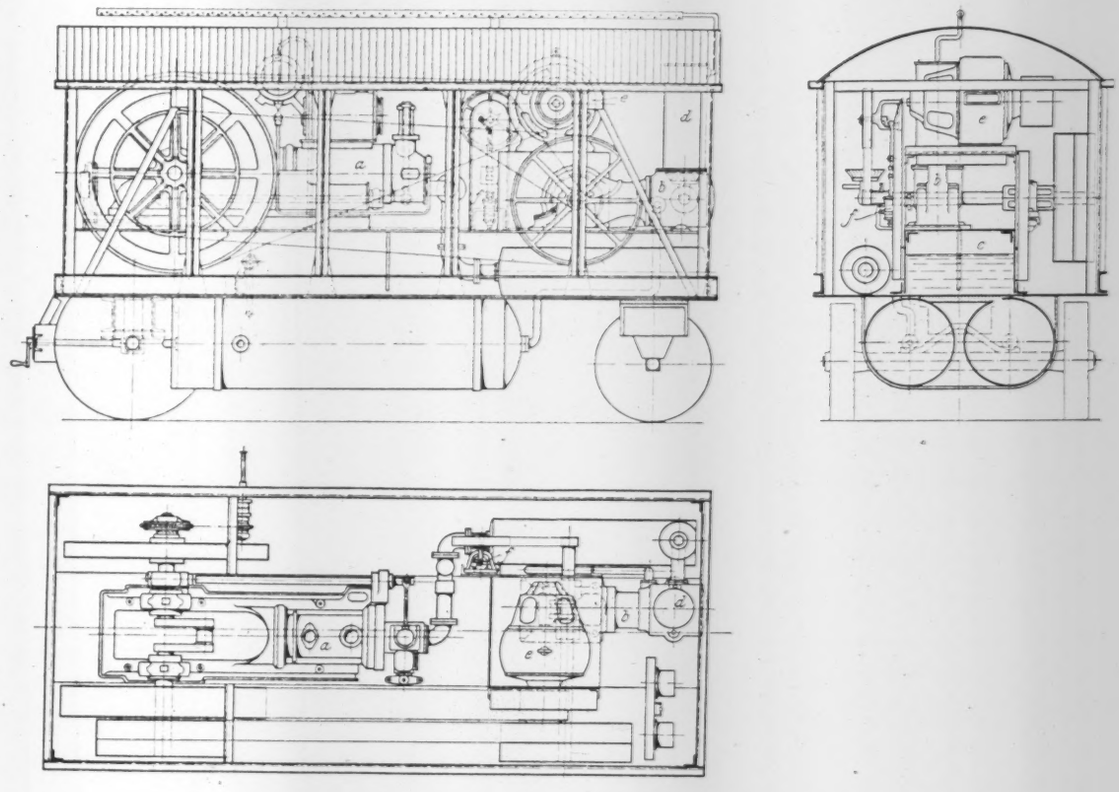


Fig. 1 Portable Air Compressor and Dynamo Plant

In blast furnace blowers, two kinds of regulation may be required. The more usual one, for constant output, can be brought about by means of the apparatus shown in Fig. 2 A. The governor drive is effected by means of oil pressure transmission from the turbine to a spring loaded piston *a*, actuating the main steam valve *b*. The steam admission is controlled by the centrifugal governor *c*, limiting the maximum speed of rotation, while the output is controlled by the auxiliary piston *d*. This latter is acted upon from below by the pressure in the blower pressure piping and from above by an apparatus *e* (known as the Rateau Multiplicator) which produces a pressure inversely proportional to the amount of air flowing through. The spring *f* contracts in proportion to the pressure difference and adjusts the regulating disc so that when the amount of air delivered becomes too great, the throttling valve is partly closed, which leads to the decrease in the speed of rotation of the turbine. If on the other hand, it is desired to have a constant pressure, a similar apparatus is used, but the multiplicator is eliminated so that above the piston *d*, the pressure is atmospheric.

One of the most important auxiliaries of a turbo blower governor is a device the purpose of which is to prevent "pumping." As used by Brown, Boveri and Company and shown in Fig. B, it consists of an automatic exhaust valve *c*, which at all times permits the escape of at least enough air from the pressure piping into the atmosphere or suction piping so that the amount of air taken in is at all times larger than that at which the blower could start "pumping." The regulating organ proper is the piston *a*, the lower part of which is at all times exposed to the dynamic or static pressure from the pressure piping while on the upper side, there is a partial vacuum produced either by means of the "multiplicator" or by simple throttling and is proportional to the amount of air delivered. Should the latter become too small, the piston goes down and through the small governor disc and permits at *e* the exit of the regulating compressed air, as a result of which the pressure of the latter below the piston *b* decreases (on account of the constant dimensions of the small exit at *f*). Thereafter, the spring *d* overcomes the opposition of the compressed air and opens the exhaust valve *c*. Since the par-

tial vacuum on the piston *a* is proportional to the amount of output, the stroke of the controlling valve, because of the presence of the spring *g*, will vary in the same sense, while the stroke of the exhaust valve will be approximately inversely proportional to the amount of air handled. In this way an arrangement can be made which would stop the efflux at a definite amount of air sharply above the "critical" limit. Fig. I to V in C show the various possible arrangements of the exhaust valve. (*Die Dampfturbinen und die Turbogebläse an der Schweiz. Landesausstellung Bern* 1914, Professor A. Stodola, *Schweizersche Bauzeitung*, vol 65, No. 3, p. 24, January 16, 1915, serial article, not finished, *d*).

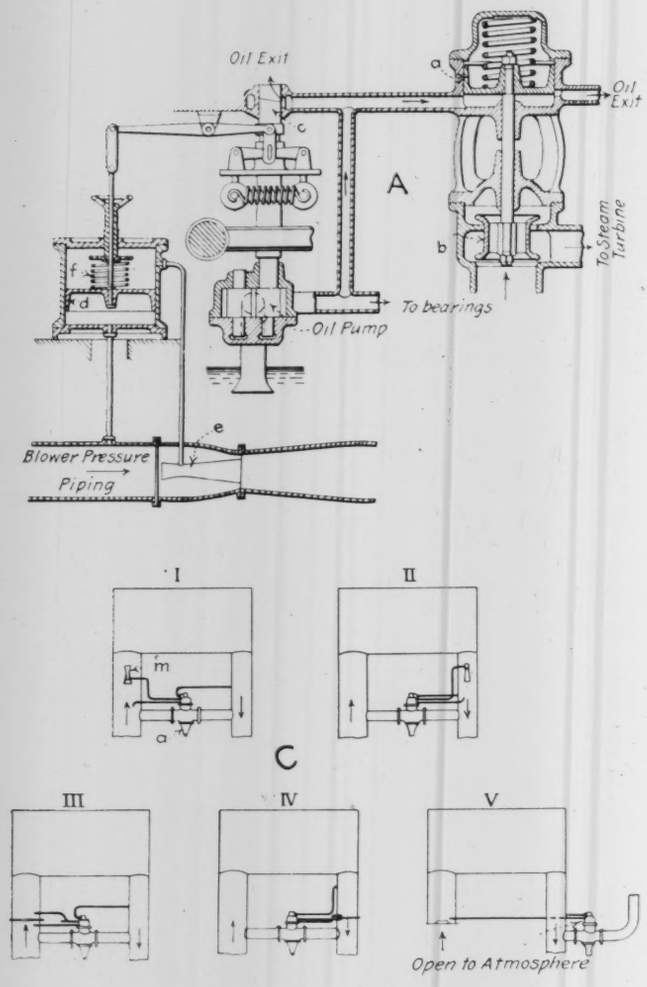


FIG. 2 TURBO-BLOWER GOVERNING DEVICES

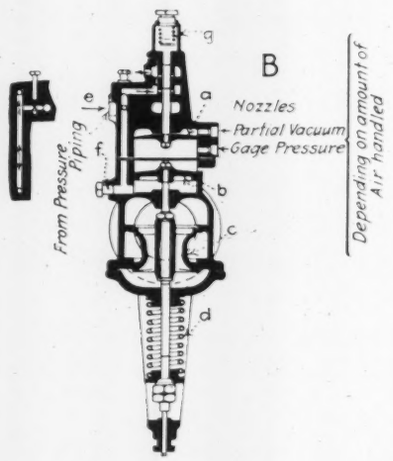
Gas Producers

GASIFICATION OF ROUGH LIGNITE.

The article describes a gas producer for rough lignite and tests of the same. The producer is of the Blezinger type previously described in The Journal (November 1913, p. 1692.).

Previous to charging, one of the two grate bars is heated up with a mixture of wood and lignite and carried under one of the empty gas producer shafts. The height of the fall of the coal is determined by the properties of the fuel used and may be varied by raising or lowering the hopper pipe in the shaft. The temperature in the zone of gasification is approximately 800 deg. cent. (1472 deg. fahr.) and this heat is used for the gasification of the coal and vaporization of the water. If the gas temperature is too high, the hopper is raised and the height of fall increases. If the gases are too cold, it shows that the height of the fall is too great and this is remedied by a corresponding lowering of the hopper pipe. At a temperature below 100 deg. cent. (212 deg. fahr.) the water originally contained in the lignite is found in the gas stream in the form of tiny bubbles rather than of steam.

The gas is cooled in a washer to a temperature of about 20 deg. cent. (68 deg. fahr.) which eliminates any water so that it reaches the place of combustion technically pure. At the same time, the major part of the tar is also taken out and may be used as a valuable fuel for driving Diesel engines, heating smelting furnaces, etc. By further processes of cleaning, for example by means of centrifugals, the lignite gas can be excellently adapted for use in gas engines. The gas producer itself requires practically no



attendance during its operation as the admission of lignite is done mechanically and regulated automatically.

As shown in Table 1 most of the German lignites have been tested in these gas producers. When the gases were used in a Lancashire boiler the useful effect of over 80 per cent of the combustion zone—that is, in the front part of the fire tube was obtained with temperatures of 1200 to 1250 deg. cent. (2192 to 2282 deg. fahr. by a Wanner pyrometer) while the temperature of the flue gases was only 190 to 220 deg. cent. average (374 to 428 deg. fahr.). This shows that there was a fall in temperature across the boiler of about 1000 deg. cent. (1800 deg. fahr.).

There can be absolutely no deposit of impurities in the flues and with proper regulation of air admission the combustion is absolutely free from smoke or dust. The profit from the saving of tar, which is taken at 2 per cent, is quite sufficient to cover the wages of the help at the producer. The main advantage claimed for this type of producer, however, lies in the fact that it permits the gasification of lignites containing high percentages of water (as high as 45 to 60 per cent) which hitherto could only be

used to a very limited extent. (*Vergasung von Rohbraunkohle,* R. Klostermann, *Giesserei-Zeitung,* vol. II, no. 24, p. 633, December 15, 1914, 4 pp., 3 figs. *de.*)

Mechanics

NOTCH SHOCK TESTS AND THE LAW OF SIMILARITY

The article reports experiments made in order to determine whether the law of similarity applies to notch shock tests.

The International Association for Testing Materials, at the Congress held in 1909 in Copenhagen, has accepted certain regulations for notch shock tests, such as the variation between the energy of blow and cross section of rupture, which the German Society for Testing Materials has called "specific energy of blow." The latter also adopted a small bar geometrically similar to the standard bar, but one-third the latter in all dimensions; that is, 1 cm. on the side of a square section, and the distance between supporting 40 mm. instead of 120 mm. It was expected that the proportional dimensions of both bars would permit the comparison of specific energies of blow and the Report of the Society in this connection calls attention to the experiments of Revillon which are claimed to have established the fact that when proportional bars were used, the specific energies of blow are equal.

The author for several years has held that the Revillon experiments were not conclusive and that considerations derived from the law of similarity would indicate that such an assumption ought not to be made without full tests. According to the law of similarity, one would expect that energies of blow would be related to each other as the cubes of the respective dimensions of bars and that therefore a bar one-third as large would require only 1/27 part of the energy consumed by the standard bar. On the other hand, the International specification assumes that the energies of blow would vary as the squares of the dimensions of the bars, or that the smaller bar would require only one-ninth of the energy necessitated by the larger bar. This discrepancy could be solved only experimentally and the second part of the article describes experiments made by the author for this purpose. (Fried. Krupp Co. of Germany defrayed the cost of these experiments.)

Charpy pendulum hammers having a capacity of 110, 75 and 10 kg—m. were used, after careful previous testing and with the resistance at no-load swinging of the hammer taken into consideration. For purposes of tests, bars were used of square section, 3 cm. and 1 cm. on each side of section, the diameter of the notch being 6 mm. and 2mm. The notches otherwise were entirely similar and reached down to the middle of the bar. The distances between supports were respectively 120 and 40 mm. Most of the bars used for the 1 cm test were made from the 3 cm bars of carbon steel, nickel, and chrome-nickel steel.

In all cases, it was found that to break the smaller bar a larger amount of energy was necessary than accorded with the law of proportionality. It was found also that the assumption of the International Association for Testing Materials made as a basis for test specification, viz. that the 3 cm and 1 cm proportional bars have the same values for the specific energy of blow is not even approximately correct, which might have been expected. What was less to be expected is that the energies of blow do not vary as the cubes of the dimensions of the bars and that the law of proportionality therefore is not applicable to notch shock tests. After it has been established that within the limits used in the experiments, the velocity of blow has no influence on the results and that there were no errors

TABLE 1 TEST OF A BLEZINGER GAS PRODUCER ON GERMAN ROUGH LIGNITES

		Composition of Coal, in per cent						Heat value (lower) determined by calorimeter WE (conversion factor to B.t.u. per lb. = 1.8)	Composition of Gas, in per cent of volume								Cub. meters of gas per kg. of coal per cent	Efficiency of gas producer, per cent	Combustible material in ash, in per cent of fuel	Temperature of gas, deg. cent.
		C	H	O+N	S	Ash	Water		CO_2	C_2H_2	O	H	CH_4	CO	N	Combustible constituent	Lower heating value			
Rough Lignites, German	1	36.63	3.19	15.19	0.22	8.37	36.40	3158	5.90	0.50	0.2	13.9	2.40	25.2	51.90	42.0	1410	1.995	89.06	..	78
	2	25.17	2.12	12.10	0.41	7.85	52.35	1932	10.20	..	0.1	6.9	3.50	22.7	56.60	33.1	1166	1.278	77.13	..	78
	3	23.69	1.96	9.61	0.10	1.44	63.20	1793	8.70	0.30	0.3	11.2	1.00	18.6	59.90	31.7	988	1.538	84.75	..	78
	4	29.29	2.22	9.13	1.19	6.71	51.46	2321	9.10	1.20	0.3	9.3	1.30	17.8	61.00	32.7	1160	1.842	82.25	31.78	80
	5	29.29	2.22	9.13	1.19	6.71	51.46	2321	7.70	1.00	0.6	9.8	2.20	20.1	58.60	31.3	1300	1.750	87.53	31.78	75
	6	28.60	2.80	11.80	0.40	6.40	50.00	2412	7.86	1.40	1.0	9.2	1.70	17.3	61.50	29.6	1141	1.868	88.36	..	89
	7	29.30	2.15	11.83	0.24	3.92	52.48	2310	8.00	1.00	..	10.6	2.10	19.8	58.50	33.5	1219	1.763	85.37	41.00	78
	8	33.46	2.81	10.15	0.92	9.76	42.90	2972	7.20	0.80	..	11.9	1.60	20.0	58.50	34.3	1182	2.091	83.16	..	72
	9	23.62	1.79	10.18	0.18	2.72	61.51	1833	8.90	0.85	..	12.7	1.44	19.5	56.61	34.5	1185	1.423	91.90	..	83
	10	26.70	1.80	11.01	0.12	1.44	58.93	1973	9.40	0.20	0.3	11.3	1.50	15.1	62.20	28.1	912	1.880	86.87	..	73
	11	34.90	2.86	10.48	0.58	5.86	45.32	3050	7.40	0.30	0.1	10.9	0.10	20.6	60.60	31.9	963	2.281	72.03	..	78
	12	31.90	2.88	9.59	0.88	7.78	46.97	2787	7.50	1.10	..	10.7	1.30	22.1	57.30	35.2	1239	1.846	82.07	..	75
	13	31.90	2.88	9.59	0.88	7.78	46.97	2787	7.20	0.70	..	9.8	1.70	21.4	59.20	33.6	1163	1.903	79.42	..	73
Briquettes from German Lignites	1	53.57	4.49	14.53	1.70	9.63	16.17	4908	4.90	0.10	..	9.8	2.20	29.0	54.00	41.1	1424	2.733	79.30	..	270
	2	52.64	4.07	13.68	1.15	9.04	19.42	4752	7.60	0.80	..	12.1	2.70	21.6	55.20	37.2	1332	2.974	83.36	..	292
	3	47.70	3.85	14.84	1.13	12.64	19.84	4498	4.60	0.80	..	15.9	2.80	22.7	53.20	42.2	1470	2.856	85.21	..	300
	4	51.26	2.96	20.16	0.26	7.83	17.53	4531	3.60	0.20	0.1	12.3	3.60	28.9	51.30	44.8	1534	2.841	85.75	..	450
	5	62.47	3.79	8.73	3.20	16.74	5.07	5928	4.00	..	..	10.4	4.10	23.2	58.30	37.3	1522	3.396	84.77	..	410

of observation which might account for this fact, one can only ascribe it to the fact that the assumption concerning the law of similarity has not been satisfied in the test bars. This assumption is the *similarity of structures:* apparently, instead of having in the two cases proportional structures, there were similar structures. This is explained in the following manner: both the larger and smaller test bars, made of such crystalline materials as steel, consisted of grains of approximately equal size.

If, however, the rupture occurs along the lines of the crystalline formation, one can easily see that in regard to the rupture in bars otherwise proportional to each other, there exists not a proportionality but an equality. This is because when the rupture occurs along the faces of crystallization, it occurs really along the surfaces of the least resistance, and one may just as well assume that the crystalline grains are divided from one another by comparatively thin layers of material of little resistance. This will be clearer if we assume that these thin layers are located

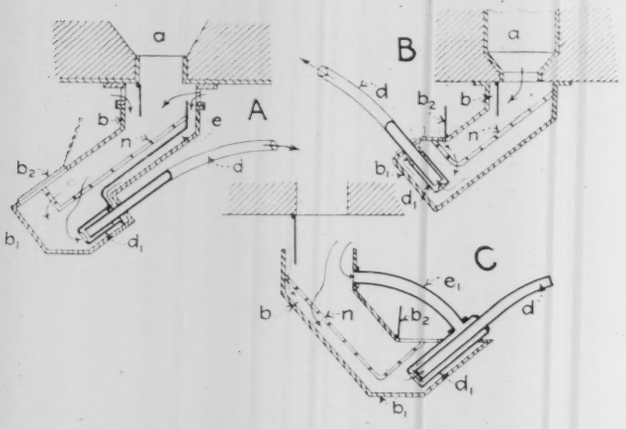


FIG. 3 DEVICES FOR REMOVING BY SUCTION ASHES AND SLAGS

parallel to the plane determined by the notch and direction of blow. In that case, the proportional bars would consist of thinner and thicker layers of very low mechanical resistance and, although the dimensions of the bars may be different, the thickness of the respective layers would be the same. Let it be assumed further that the central plane of the notch falls in the middle of the thin divided layer and that the notch of the larger bar does not reach the limits on both sides of the thin layer of divided material. If the permanent deformation which occurs at the blow, extends only to the layers of low resistance located in the plane of the notch, the volume of which is proportional to the square of the dimensions of the bars, one cannot expect that the energy of blow will be proportional to the *cube* of the respective dimensions.

The most characteristic element of the example, the fact that the thickness of the layer undergoing deformation is independent of the ratio of dimensions, is especially evident in the case of brittle materials. In the case of tough materials, the variation between the thickness of the volume subject to change of shape is approximately proportional to the dimensions of the bars. Accordingly, the ratio of specific energies of blow in the case of bars of proportional dimensions is variable, and is unity for fragile materials. For tough materials, it varies approximately as the dimensions of the bars. It appears, therefore, that no general rule can be established and that at any rate, the law of similarity is not generally applicable to this case. (*Die Kerbschlagprobe und das Aehnlichkeitsgesetz*, R. Stribeck, *Zeits. des Vereines deutscher Ingenieure*, vol. 59, No. 3, p. 57, January 16, 1915, 4 pp., *el*).

Steam Engineering

DUST-FREE SUCTION OF ASHES AND SLAGS

The article describes devices for removing by suction ashes, slags, etc. from a grate without permitting dust and hot gases to escape into the outside atmosphere.

Wherever the ash removal by suction is effected by the use of a completely closed chamber, the admission of fresh air from the outside is effected by a separate admission nozzle. There are, however, a good many cases in which an absolute exclusion of air all along the path of the ashes is for various reasons, impossible, and in this case one has to reckon with the serious disadvantage of having dust and hot gases escape on all sides. The device described in this article is claimed to eliminate this disadvantage by taking in the air for the working of the apparatus at the very places through which the dust and gases would otherwise escape.

Three designs of this apparatus are described and illustrated in the article. In the first one, a suction chamber b is assumed to be entirely open on top, which corresponds to a condition in which no airtight closing of the top is possible. The suction chamber b is shaped downward somewhat like a sack, the upper part b being separated from the lower part b^1 by a grate n. It is of advantage to place this grate in an inclined position and to arrange it in such a manner that it would force all the ash and slag to move toward the suction nozzle in order that the latter may have a chance to break up too large pieces of slag. This is the reason why the door b_2 is provided, giving admission both to the grate and to the tip of the suction nozzle d_1. When b_2 is closed, all the air required to force the material through the delivery pipe d is taken from above and it is impossible therefore that dust or gases should escape that way.

When larger amounts of slag or ashes drop in suddenly however, or other disturbances take place, it may happen that material would heap up on the grate, and care must be taken therefore to admit sufficient air to the suction nozzle tip d_1 to handle this excess of material. For this purpose, under the grate, a special passage e is provided which is always open on top and which admits the air taken from above through the nozzle tip d_1 to the suction pipe d, as shown by arrows in the drawing. In this case also, the fact that the air is taken in from above prevents the dust from escaping that way. But even when (in order to eliminate such disturbances as may occur) b_2 is left open, the admission of air for operating the suction device still remains sufficiently large to prevent the exit of dust at that place while the air is being sucked in through it.

In the second design shown in Fig. B, the suction chamber b is rigidly connected with the ash exit a. The material falls on the inclined grate n where exceptionally large pieces are broken up in this case also by the door b_2. The air admission to the suction nozzle d_1 occurs through an

opening in b_2 which remains entirely open, and the air is permitted to flow both through the grate and underneath it in a manner indicated by the arrows, so that in this case, even with an open damper b_2, the dust cannot escape.

Finally, in the third design, Fig. C, the chamber b is again assumed to be open on top. Ash and slag fall on the grate n and the suction air is again taken from above, but in this case the air is admitted to the suction nozzle d_1 through the damper b_2 and in addition to that an intermediary pipe e_1 is provided, connecting the upper part of the suction chamber b with the nozzle pipe d, thus admitting fresh air to the latter as required. (*Staubfreie Absaugung der Asche, Flugasche, Schlacke usw. aus den Asche kammern bei Verbrennungsanlagen aller Art, bei welchen das Gut durch einen Rost tritt*, Fritz Hartmann, *Rauch und Staub*, vol. 5, No. 1, p. 7, October 1914, 2 pp., 3 figs. *d*.)

Relation Between Quality of Steam and Load on the Boiler in the Case of a Cornish Boiler

The article reports test data on investigation showing the relation between wetness of steam and load on the boiler, in the case of Cornish boilers.

The tests were carried out in the experimental laboratory of the Bavarian Association for Boiler Inspection. The boiler has a longitudinal corrugated flue (Fig. 5 A), located off the center line. The boiler was put up in 1903 by the Augsburg-Nuremberg Machine factory for 13 atmospheres gage pressure. Its main dimensions are indicated in millimeters on the figure. After the hot gases leave the flue, they pass forward along the right side of the boiler, then back along the left side of the boiler, and finally escape through the smoke stack, 40 m (131 ft.) high and 0.7 m (27.5 in.) diameter of top opening. During the test, the superheater which belonged to the boiler, was separated from the fire tubes by a wall. The feed water was supplied by a duplex steam pump through a simple pipe introduced in the middle of the last section of the shell and the steam was taken out through a dome. In addition to the steam taken for the quality test, a certain amount of it was also delivered to the pump. The steam to be tested left the dome through a quarter bend directed upwards, traveled through an angular valve, then into a throttling calorimeter in the same manner as was used previously by the same laboratory for the water tube tests, and was finally exhausted into the atmosphere through a long pipe crossing the boiler room and the engine room.

On the Cornish boiler, eight tests were made with the throttling calorimeter the results of which are in the main given in Table 2. Fig. B shows the functional relations between the amount of steam produced per sq. m. of boiler heating surface and the total amount of moisture in front of the throttling valve. In order to be able to compare data previously obtained on water tube boilers with those of the Cornish boiler, the curve for the total moisture of the water tube boiler was also plotted. The figure shows that in the case of the Cornish boiler as well as in that of the water tube boiler, the moisture in the steam decreases with the increase of load, but the comparison of the two curves shows that the water tube boiler produces steam of greater moisture than the Cornish boiler and the percentage of moisture in the latter boilers is less than in the former.

Die Abhängigkeit der Dampffeuchtigkeit von der Kesselbelastung bei einem Einflammrohrkessel, Zeits. des Bayerischen Revisions-Vereins, vol 18, No. 22, p. 203, November 30, 1914, 3 pp., 2 figs. *e*).

German Progress in Steam Boiler Firing

Description of various new inventions in the field of steam boiler firing, patented in the last quarter.

H. Brams patented in Germany (No. 278513) a grate with automatic stoking and cleaning, provided with longitudinally located grate bars. As shown in Fig. 4 A, it consists of an internal rotatable pipe and other pipes ex-

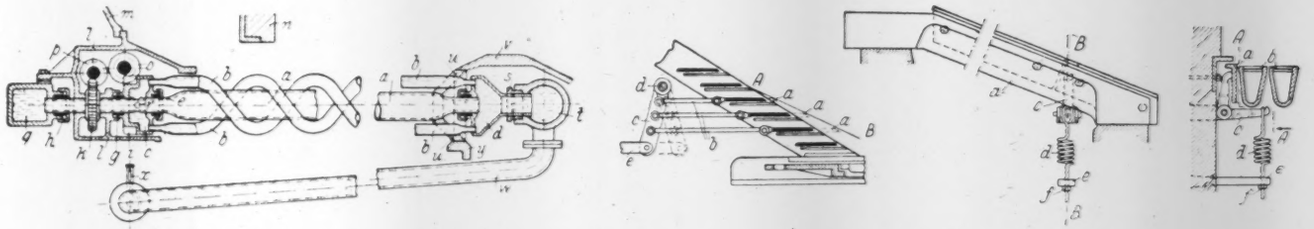


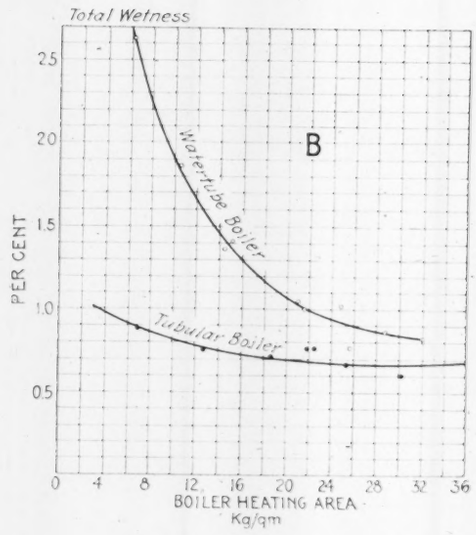
FIG. 4 RECENT TYPES OF BOILER FURNACE GRATES

ternally and helically wound around it. The movement of this pipe can occur in such a manner that the internal pipe may either rotate or remain stationary while the external spiral pipes rotate either in the same or in opposite direction. This arrangement, in which the inner pipe rotates one way and the outer pipes rotate in the opposite direction, is claimed to be most appropriate for all kinds of fuels and is also very simple. One or more of the helically wound pipes b around the straight line pipe a of the grate bar help to move the fuel forward to the fire bridge. The cooling liquid flows through the water chamber q located crosswise across the entire width of the grate, the ends of the pipe a being screwed into the chamber through the stuffing boxes h. At r the pipes have openings located circumferentially, through which the liquid can flow into a rotatable hollow element c, placed about the pipe a. At e and g, the hollow element is rotatably fixed with proper packing about the inner tube. The ends of the helical pipes b, distributed symmetrically around the circumference, open (water-tight) into this hollow element c.

The drive of the grate is through worms o and p and is regulated in accordance with the speed of the fuel delivery on the grate. The internal pipe carries wheels k which are in engagement with the worm p while the hollow element c

is provided with a toothed wheel *i* in engagement with the worm *o*. The whole drive is located near the gear box *l* and the regulation of the hopper delivery is effected through the hopper door *u*. At the fire bridge end of the grate, the pipes *a* open into a rotatable hollow body *d* into which also open the external pipes, through water-tight joints. All the hollow bodies are connected through stuffing boxes *s* with the collector pipe *t* from which the cooling water is taken by the pipes *w*. At that point the temperature of water is read by a thermometer *x*. A regulating valve permits the control of velocity of flow of cooling water through the grate in such a manner that there is no scale deposit in the grate elements. In order that clinkers may not get into the packing and stuffing boxes, rotating elements *u* are provided and placed rotatably to the plane of the fire bridge so as to deflect them in falling.

In regard to inclined grates, the invention of F. Albrecht, (German patent No. 276,548) is somewhat of a novelty.



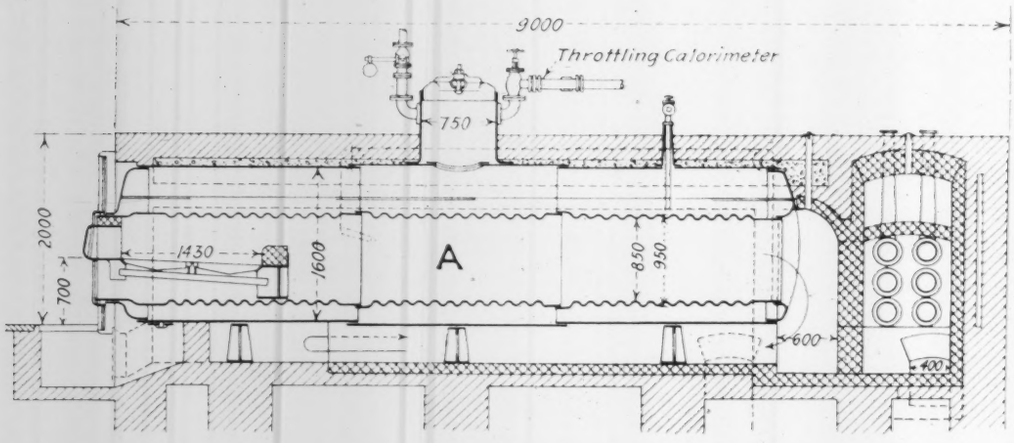


FIG. 5 PLANT USED FOR TESTING THE RELATION BETWEEN LOAD ON BOILER AND WETNESS OF STEAM, AND CURVES SHOWING RESULTS OBTAINED

TABLE 2 RELATION BETWEEN QUALITY OF STEAM AND LOAD ON BOILER WITH CORNISH BOILERS

No. of Test	Feedwater consumption per hr., kg./conv. fact. to lb.—2.2	Water of condensation from steam pump, kg./conv. fact. to lb.—2.2	Steam per hr. in front of the throttling disc, kg./conv. fact. to lb.—2.2	Water of condensation, per hr., in front of the throttling disc, less loss in metering device, kg./conv. fact. to lb.—2.2	Gross wetness, per cent	Bore of the throttling disc, mm./conv. fact. to in.=0.039	In front of throttling disc: Absolute steam pressure, atmospheres	In front of throttling disc: Corresponding temperature of saturated steam, deg. cent.	In front of throttling disc: Temperature as indicated by thermocouple, deg. cent.	Absolute steam pressure, atmospheres	Corresponding temperature of saturated steam, deg. cent.	Temperature of cold soldered joint, deg. cent.	Behind throttling disc: Thermoelements I	Thermoelements II	Thermoelements III	Thermoelements IV	Average steam temperature, deg. cent.	Superheat, deg. cent.	Quality (without regard to velocity), per cent.	Quality (velocity considered), per cent.	Total wetness of steam in front of throttle, per cent.
2	279	37	242	0.50	0.21	8	11.1	183.5	184.3	1.7	114.5	29.0	152.0	150.1	....	151.7	151.3	36.8	0.68	0.67	0.88
3	512	38	474	0.57	0.12	11	11.2	183.9	185.0	3.2	134.9	32.3	157.1	157.4	155.5	157.8	156.9	22.0	0.64	0.63	0.75
4	750	47	703	0.25	0.04	14	11.4	184.6	185.4	1.7	114.5	27.8	150.2	152.1	151.4	150.3	151.0	36.5	0.76	0.68	0.71
5*	903	51	852	...	...	15	11.4	184.6	184.5	1.9	118.0	25.8	149.4	152.2	151.7	150.4	150.9	32.9	0.86	0.76	0.76
7*	881	53	828	0.12	0.01	15	11.1	183.5	183.2	1.8	116.3	28.7	149.5	149.1	151.5	149.9	150.0	33.7	0.85	0.75	0.76
6	1018	55	963	0.03	0.00	16	11.0	183.1	183.3	2.1	121.0	27.7	150.9	152.5	152.5	151.1	151.8	30.8	0.76	0.66	0.66
8	1210	64	1146	0.16	0.01	17	11.0	183.1	183.4	2.3	123.7	29.6	152.6	152.0	153.8	152.6	152.8	29.1	0.71	0.59	0.60
9	1430	71	1359	0.13	0.01	19	11.1	183.5	182.0	2.6	127.9	26.8	153.0	153.0	154.6	153.0	153.4	25.5	0.79	0.66	0.67

* Comparison of No. 7 to No. 5

Each grate bar consists of a frame the two parts of which are connected by a cross-piece. In this frame, stepped plates can be inserted and held on the side away from the fire. It is important to notice that the frame itself is open from behind and this permits of shoving the stepped plates quite far into the frame. In actual practice, it was found that to afford the plates an opportunity to cool they must be made so their depth is greater than their width.

Ph. Werger, who has previously patented an inclined step grate system of firing with hollow grate bars movable longitudinally, has now introduced a further improvement (German patent No. 277,330) which consists in the fact that the cheeks of the grate can be pressed against the grate bars by an angle lever which may be operated from outside either by a spring or by a weight. Fig. C and D show one design of this new type. The movable cheeks *a* which do not take part in the longitudinal motion of the other grate bars *b*, are pressed against them by the angle lever *c*. The horizontal arm of this lever located under the grate, is operated by means of a helical spring *e*, rigidly fixed on the fire wall in such a manner that the tension of that spring and therefore the pressure of the bar *a* against the grate bars *b*, could be adjusted as desired. (*Neue Patente auf dem Gebiet der Dampfkesselfeuerung*, Pradel, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 38, No. 4, p. 27, January 22, 1915, serial article, not finished, *d*).

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

No. 97, January 1915.

Depreciation as Applied to Oil Properties, P. W. Henry
Coal-Dust Fired Reverberatory Furnaces of Canadian Copper Co. David H. Browne (abstracted)
Safeguarding the Use of Mining Machinery, Frank H. Kneeland
Experiments on the Flow of Sand and Water through Spigots, R. H. Richards and Boyd Dudley (abstracted)
Coal-Dust Fired Reverberatories at Washoe Reduction Works, Louis V. Bender (abstracted)

COAL-DUST FIRED REVERBERATORY FURNACES OF CANADIAN COPPER CO., David H. Browne.

The paper describes coal-dust fired reverberatory furnaces, taking up also to a certain extent the history of the use of coal-dust for metallurgical purposes in Northern America. In the early part of the development, about 1909, it was found that at Highland Boy and Cananea, there were two mechanical difficulties encountered, stoppage of flues with the accumulation of ash, and interruptions and irregularities in the coal-dust feed. At the same time, the practice of cement plants demonstrated that the operations of feeding and burning pulverized coal could be made quite continuous, uniform, and well regulated provided that the proper methods were used in the preparation of the coal.

In the new plant means were provided both for preventing possible accidents and for regular operation of the plant. Especial care was taken to specify that all bins, conveyors, etc., for the pulverized coal should be made as nearly dust-proof as possible by the use of rubber gaskets to eliminate the danger of dust explosions. Further, to obviate the possibility of trouble from the accumulation of coal ash, an entirely new arrangement of the furnace flue was designed to provide a straight-away course for the gases. In doing this, the skimming door was taken from its traditional position at the end of the furnace and placed on the side without entailing thereby any material sacrifice. As built, the original furnaces were lined with basic brick and the hearth was an inverted arch of magnesite.

The furnaces went into operation before any proper means of drying coal dust were provided and during the winter of 1911-12 a large amount of the charge, wet and frozen as it came from the piles, was shoveled in through the doors of the furnace. All the converter slag was poured in at first through an opening in the roof and later by means of an iron chute through a door near the fire end. The introduction of so much cold air and cold material prevented any satisfactory fuel ratio which at first was 6.7 tons of total charge per ton of coal but only 2.2 tons of cold charge per ton of coal. The combustion of the fuel, however, was satisfactory from the start, no trouble being experienced either in grinding or burning the coal. The ash, while working on cold charges, choked and clogged the flue at the throat and this difficulty was not eliminated until hot calcine was used and a larger tonnage was smelted. In general, the slower the furnace is working the cooler is the ash and the more it sticks and accumulates, while the faster the furnace is driven the less does the ash hang back in the furnace, and with rapid smelting it becomes a negligible factor.

During the following years, improvements in the construction of the furnaces were made. Long and shallow pockets were provided along the side walls, and through holes in the roof green ore fines were fed to protect the sides. This led to the bricking up of the doors of the furnace and the marked improvement which resulted from the exclusion of cold air and the insulation of the walls by a non-conducting and continuously renewed blanket of fines brought about the extension of this side fettling system to take in almost the entire charge of calcines. Further, as the walls were thoroughly protected by the charge, the use of basic brick in the walls and hearth was no longer necessary and it was changed to the siliceous bottom and the customary siliceous brick walls. The fuel ratio also improved very materially.

The article describes in detail the construction of the furnace. The coal-dust is introduced through five pipes 5 in. in diameter. One of these pipes is on the center line of the furnace; the others are in horizontal line with it at a distance of 3 ft. 3 in. from center to center. The coal used in firing is a good quality of slack, a thermal value of about 13,500 B. t. u. per lb., is about ¾ in. and under in size and contains about 7 per cent moisture. It is dried in a Ruggles-Coles dryer, 70 in. in diameter and 35 ft. long, and is then ground in Raymond impact mills so that about 95 per cent passes a 100 mesh and 80 per cent passes a 200 mesh screen. Any coal delivery pipe can be closed off by a slide gate and any screw conveyor can be stopped by disconnecting the beveled gears attached thereto. In this way any desired number of the five burners can be run and at any desired rate within wide limits.

The amount of air delivered to each nozzle can be varied at will or cut off entirely. As a rule all five burners are in operation, each delivering 13.5 tons of coal-dust a day. The air is supplied by a 4 ft. Sturtevant fan running at about 1300 to 1400 r. p. m. The air supplied by this fan is insuffi-

cient for the combustion of the fuel, and openings are left in the end wall between the coal burners, which are stopped by loose bricks so that the amount of air is readily controlled. (12 pp., 2 figs. *d*).

COAL-DUST FIRED REVERBERATORIES AT WASHOE REDUCTION WORKS, Louis V. Bender.

Description of coal-dust-fired reverberatories and results obtained therefrom.

The reverberatories at Washoe Reduction Works described in this paper have been made after an investigation of the Canadian Copper Company plant described in the preceding abstract. The coal from the storage bin is delivered to a 30 in. x 30 in. Jeffrey single roll coal crusher where it is reduced to 1 in. maximum size. It is then taken up by a belt conveyor to the foot of an elevator, passing over a Ding magnetic pulley which removes any pieces of iron, bolts, etc., and elevated and fed by gravity into a 40 ft. x 6 ft. 8 in. Ruggles-Coles drier. From here, the coal is lifted by a screw conveyor and discharged into a steel bin placed above the pulverizer, which is in a separate building from the drier. A Raymond five-roller mill is used with an average hourly capacity of 4.5 tons. To this mill is connected a fan from which air is admitted underneath the grinding surface, the material being taken away by the air current as quickly as it is reduced by the rolls and blown into a Cyclone dust collector placed 20 ft. above the pulverizer. The finished product is discharged through a spout

TABLE 3 COMPARISON BETWEEN FURNACES USING COAL ON GRATES AND COAL DUST

Furnace	Tons Smelted per Furnace Day	Total Tons Smelted	Tons Coal	Fuel Ratio		
					Excluding Drier Coal	Including Drier Coal
No. 7	250.96	7260.31	1870.94	3.88	....	....
No. 8	475.75	14272.52	1984.77	....	7.19	7.08

at the bottom of the dust collector and is taken up by a screw conveyor to a bin placed near and above the furnace.

The method of introducing the coal from the bin into the furnace is similar to that used at the Canadian plant. The amount of coal fed is determined by the speed of the screw which is easily regulated by a Reeves variable speed regulator. The entire grinding, conveying and bin system, from the driers to the burners is air tight so far as practicable, with the result that the entire plant is extremely clean and free from dust. The ash gives very little trouble. The article contains data on the coal used and the results obtained. As to the latter, a table showing the comparison between the working of two reverberatory furnaces, one using coal grate firing and the other the coal dust firing; is given in Table 3. (9 pp. 2 figs. *d*.)

EXPERIMENTS ON THE FLOW OF SAND AND WATER THROUGH SPIGOTS, R. H. Richards and Boyd Dudley.

The article describes experiments on the flow of sand and water through spigots, performed in the ore dressing laboratory of the Massachusetts Institute of Technology, for the purpose of securing data as to the relation between composition and viscosity of mixtures of sand and water. The problem to be solved particularly, as it is often encountered, belongs to the following class:

With a given quantity of solids per unit time, of a given specific gravity, to be discharged with water under a given head, and with a given ratio of water to solid, what must be the size of the spigot opening?

One of the factors affecting the solution of the problem is the viscosity of the material to be discharged and in this case the term "viscosity" has a somewhat special meaning in that it denotes the ratio of the volume of pure water that will flow through a given orifice under a given head in a given time, to the volume of the material under consideration that will flow through the same orifice in the same time under the same conditions. While the actual viscosity of water containing sand in suspension is not increased by the presence of the sand, still the volume rate at which the mixture will flow through an orifice is less

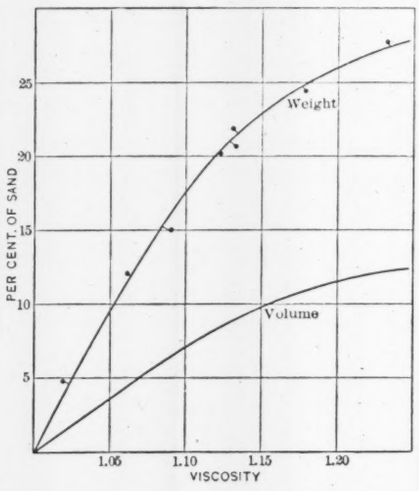


FIG. 6 CURVES SHOWING RELATIONSHIP BETWEEN COMPOSITION AND "VISCOSITY" OF MIXTURES OF SAND AND WATER

than that at which pure water will flow by reason of the friction of the particles of sand against each other and against the sides of the orifice. In other words, the flow is retarded as it would be by increased viscosity. Generally the area of the spigot opening can be calculated from the equation.

$$a = \frac{fq}{c\sqrt{2gh}}$$

in which a is the area of the spigot opening; f the viscosity of the mixture; q the rate of discharge by volume; c the coefficient of discharge; g, acceleration due to gravity and h the head of water above the spigot.

The apparatus used in the test and shown diagrammatically in the article, consisted of a cylindrical tank of galvanized iron, having a conical bottom to which the spigot was attached and a mechanical feeder for delivering dry sand to the tank. By feeding enough water into it to supply the spigot in order to maintain a slight overflow, a constant head of water was maintained above the spigot. Below the tank a swinging sheet iron launder furnished the means of deflecting the spiot discharge into a bucket

for any desired time and this determined the rate of flow. The method used in conducting the test was as follows:

The tank was filled with water and the rate of influx conveniently adjusted. The feeder was then started and sand was delivered to the tank. The sand settled through the water and passed out of the spigot, thus increasing the amount of overflow not only on account of the added volume of sand but also because of the increased rate of discharge due to the passage of the sand through the spigot. When the sand and water mixture had been running from the spigot for a minute or two and the flow had become steady, the spigot discharge was deflected into the bucket for a measured length of time, usually for about 2 min. The feeder was then stopped, adjusted to deliver sand at a different rate and another test was made. The results of the experiment are shown in a table where the rates of flow are expressed in kilograms and liters per minute, while the relationship between the composition and viscosity of the mixtures is shown graphically in Fig. 6, where the ordinates of the upper curve are the percentages of the sand by weight, while those of the lower curve are the percentages of sand by volume with the viscosity of the mixture plotted as abscissæ in each case.

These tests have shown that when the amount of sand in the mixture exceeded 30 per cent by weight, the spigot would produce a very thick discharge for a short time but its continuous operation was not certain and clogging resulted sooner or later, so that the mixture of sand and water could not be sucessfully discharged from a spigot when the mixture contained more than about 30 per cent. of sand by weight (which for the sand used in these experiments corresponds to about 13 per cent of sand by volume). The following example, illustrating the use of the data given above, shows the practical value of this information. It was desired to discharge from the pocket of a classifier 40 tons of sand per 24 hr. together with water in the ratio of 1 part of sand to 3 parts of water by weight. The head of water above the spigot is 3 ft. and the form of the spigot is that of a short tube with a conical mouth at the influx end. The mean specific gravity of the sand is 2.81. What must be the diameter of the spigot opening?

The author goes through a complete calculation using the lower curve of the Fig. 6 for the determination of viscosity of the mixture, i e. f in the equation on page 188, and thus determines the diameter of the spigot opening.

INSTITUTION OF MECHANICAL ENGINEERS

Advance paper D, read January 22, 1915

STANDARDIZATION OF PIPE FLANGES AND FLANGED FITTINGS, John Dewrance.

On April 18, 1902, Mr. Robert E Atkinson read before the Institution of Mechanical Engineers, a paper on the standardization of pipe flanges and of flanged fittings. As a result of it and the discussion to which it gave rise, the matter was, in the following year, taken up by the Engineering Standards Committee which appointed a Sectional Committee on Pipe Flanges to deal with the question. This committee included representatives of the Admiralty, various engineering associations and societies, and important manufacturing firms. After having held about thirty meetings, they presented a report (British Standard Tables of Pipe Flanges No. 10, November 1904) in which the flanges are standardized into four classes according to the pressure. The report also gives standard dimensions for the short bends and tees of cast metal and for long bends of wrought iron and steel. Some of the points concerning these standards are of interest.

The diameters of flanges and bolt hole circles are uniform for flanges intended for steam pressures ranging from 55 lb. to 325 lb. per sq. in., slightly smaller flanges being given for pressures up to 55 lb. per sq. in.

One of the points which caused a great deal of discussion was whether or not the number of bolts employed should be a multiple of 4 in all cases. Hydraulic press cylinders and heads are often connected by two bolts and seldom by more than four. Cast iron pipes up to 7 in. bore for

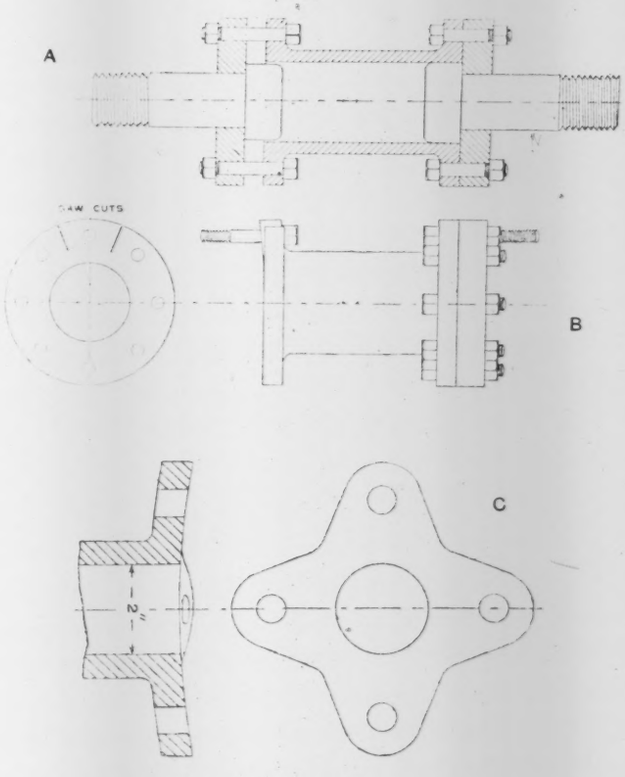


FIG. 7 STRESSES IN PIPE FLANGES

hydraulic power up to 1200 lb. pressure per sq. in. are made with two bolts, but the reason why in English practice only two bolts are used in the ends of hydraulic mains is that several pipes are laid side by side in the streets in branches and in order to be able to run the pipes in any direction standard tee bends and valves must be made in three variations,—one with the flanges vertical, another with the flanges horizontal and still a third with one flange vertical and the other horizontal. This led the sub-committee to the conclusion that there can practically be no standard at all unless the number of bolts used are multiples of 4. While four bolts would be sufficient for even the largest steam pipe flanges, the use of four bolts only in the larger

sizes would involve setting the bolt bracket on the flange back which is done in the hydraulic pipe flanges. This would require longer bolts which again would have to be much larger to stand the strain and would entail a greater cost than the use of the number of smaller bolts that was adopted. The clearance of 1/16 in. in the bolt holes for ½ in. and ⅝ in. bolts and of ⅛ in. for larger sizes was in the opinion of the sub-committee the smallest allowance that was practicable for commercial manufacture.

They did not agree to any formula as to the thickness of flanges that could be accepted for general use. The author's view is that two separate stresses have to be considered. The first is the stress necessary to distort the flange and the pipe considered as a cantilever; and the second is the stress necessary to cup the flange itself. To demonstrate this, a short piece of 2½ in. bronze pipe with two of the standard flanges, 7¼ in. in diameter and 1/16 in. thick, was made and drilled with eight holes to the British Standard (Fig. 7 A). One of the flanges was bolted up to a cast iron flange and the other flange was connected by bolts to another thick cast iron flange, leaving space between the bronze and cast iron flanges as shown in the figure. The cast iron flanges were then pulled apart in testing machines. At 17.28 tons, the last mentioned bronze flange set 1/32 in. and at 19.2 tons had a set of over ⅛ in.

Two radial saw cuts were then made in the flange, so as to bisect the distances between one of the bolt holes and the holes on either side of it, from the outside circumference of the flange to the barrel of the pipe. In this way, a one-eighth part of the flange was isolated from the rest. A bolt was passed through the hole in this isolated portion and another through the hole in the complete flange and the cantilever strength of the smaller was tested between the centers of a testing machine in the ordinary way as shown in Fig. B. A set of ⅛ in. was obtained with a load of 1.27 tons. This experiment proved that the flange owes 1.27 tons for each section of an eight, or 10.16 tons in all, to the cantilever strength and the balance of 19.2 or 9.04 tons to the strength of the flange itself.

A flange 6½ in. in diameter for 2 in. pipe and having four bolts was then taken and pulled in a similar manner. At 14.3 tons, there was a permanent set of 1/32 in. and at 16.99 tons a permanent set of ⅛ in. set. An exactly similar flange was then reduced to the shape shown in Fig. C. At 13 tons there was a permanent set of 1/64 in. and at 15.27 tons, a permanent set of ⅛ in.

This result is of great interest as it shows that formulae based on the strength of the girder between the bolts are not correct and also shows that there is an ample margin of strength when four bolts are used on a 2 in. flange. It also suggests that when it is necessary to keep the weight down as low as possible, the flange need not be round but may be a shape similar to that shown with four bolts in Fig. C, or a corresponding shape with eight bolts.

The thickness of the flanges embodied in the Standard Tables were arrived at by the sub-committee as the result of actual experiments by them. The British Standard Tables state the thicknesses for steel or wrought iron flanges welded on, the same as for cast iron flanges, notwithstanding the much greater strength of flange material in the former case.

The sub-Committee did not make any recommendations as to packings. The author states that the British Standard for pipe flanges is certainly the most largely adopted at the present time and recommends its adoption by those parts of the United States which have not already done so. (8 pp., 5 figs. *g*).

ONTARIO FRUIT GROWERS' ASSOCIATION

(*Published in Cold, vol. 6, no. 4, February 1915, Calcium, N. Y.*), *Edwin Smith.*

PRE-COOLING OF CANADIAN FRUITS

Discussion of pre-cooling of fruit in Canada with some historical data concerning the products of pre-cooling. Description of the pre-cooling plant at Grimsby, Ontario.

In designing the Grimsby plant, the type selected was of the warehouse design. Ice is used as a refrigerating medium in a Cooper Gravity Brine system. The fruit is loaded and packed as soon as picked from the trees on specially designed trucks which are then run into one of the four pre-cooling rooms. Each room holds more than a carload of boxes or baskets loaded on trucks and has a perforated floor and ceiling through which a circulation of cold air is blown from the coil room by means of large 60 in. fans. Electric thermometers are placed in the bottom and top tiers of fruit packages and as soon as the fruit is entered, the doors are closed, the fan set in motion and the cooling started. By means of the electric thermometers, the temperature of the fruit is taken from the outside and as soon as sufficiently cooled for shipment (38 to 40 deg.), loading takes place. Fruit once cooled down must not be exposed to the warm air until it reaches the market and therefore a cold corridor extends from the pre-cooling rooms with an adjustable vestibule to the refrigerator car door. Through this, the trucks of cooled fruit are run directly into the cold car, thus preventing exposure, rough and unnecessary handling of packages and greatly cutting down the work and time necessary for loading.

The season of 1914 has been an active one at the Grimsby plant, although there was no peach crop to handle. Cherries, pre-cooled and shipped to Winnipeg, arrived there in splendid condition and were sold on commission at 60 cents per basket, while at the same time other sour cherries were sold in the Winnipeg markets for from 38 to 42 cents, which speaks for the superior quality of the pre-cooled fruit. The plant acted also as a cold storage and effected great savings to the growers. In one case during the raspberry season when the canning factories were unable to receive berries that had to be handled at once, as much as four and a half cars of fruit were brought to the plant, placed in a low temperature for two or three days until the factories were again in shape, thus avoiding a certain loss of over $3000.

An interesting experiment was tried in the handling of Red Astrachan apples. These apples usually go at a fairly low price but between their season and that of the Duchess, there is a scarcity of early apples. A shipper placed his apples in cold storage prior to August 15 and then marketed them as they were demanded by the trade during the latter part of the month with a gain on the transaction.

In addition to the commercial use of the plant, an experimental scientific cold storage laboratory is connected with it and its work is of great value to the grower. As an example of what it is doing, the author cites the work done with tomatoes. Tests were made on Narliana, Chalk's Jewel and Danish Export picked at three different stages of ripe-

ness and stored in eight different kinds of packages at 32, 39 and 45 deg. It was found for example that the first two kinds are of little use for cold storage and that most of the Ontario varieties of tomatoes are too likely to crack about the stem end. A small size of tomato stores better than a large one. For storage, the tomato needs to be picked when turned to a straw color; if picked riper, it will soon become soft in storage. Tomatoes wrapped separately in the 4-basket plum crate of British Columbia kept better than those stored in open baskets. Placing the tomatoes in wood-wool proved better than wrapping, while storing in a box with a sawdust filler kept the tomatoes in the best shape, especially where they were cracked. As an illustration of the value of this class of work, the writer cites the case of a grower who came to the plant and wanted to store a carload of tomatoes until Christmas time and get the special price paid for hothouse tomatoes. He was advised against it and he would have lost the entire car had he stored the varieties of tomatoes grown.

As a matter of fact, to pre-cool fruit does not necessitate an elaborate and expensive plant. Anything that lowers the temperature of the fruit previous to shipment tends to check its ripening process and postpones decay. In British Columbia experiments have been carried on by the Provincial Department of Agriculture to show the beneficial results of using the cold night air that they have in that region and also of picking raspberries in the early morning while the dew is yet present and then removing the moisture by fanning in a dehydrator before shipping. Such an appliance cost only about $25 or $50, and its success made the growers quite enthusiastic. The practice of wet picking, however, is not to be encouraged where plenty of dry weather is to be had.

In pre-cooling fruit for express shipments, extreme care must be exercised not to overdo the work. In a series of investigations on strawberries, cooling has been found beneficial when carried on on the average of about 5 deg. below the temperature of the express cars. When cooled lower than this, the berries suffer on account of the condensation of moisture on removal from the cooling chamber, with a resultant growth of mold which was as bad or worse than when shipped hot from the patch. It must also be understood clearly that pre-cooling is not a panacea and will not make overripe or injured fruit arrive in good condition. At the Grimsby cold storage plant, it is the practice to refuse to receive fruit which is not in good condition, and the loading of cars is also properly controlled. On all long distance shipments, the fruit is raised 4 in. from the refrigerator car floor on a slotted rack and loaded so as to leave continuous air spaces. In the center of the car a space of from 2 to 5 ft. is left for air circulation and the loads in either end of the car are held rigidly in place by bulkheads and proper braces, which is considered about the most effective way of preventing trouble from broken packages. (4 pp., *pdh*).

RAILWAY CLUB OF PITTSBURGH

Vol. 14, No. 1, November 27, 1914, Pittsburgh, Pa.

FORGED AND ROLLED STEEL PISTONS, W. W. Scott, Jr.

The paper discusses the use of forged and rolled steel pistons in modern locomotives, mainly as a means of reducing the weight of reciprocating parts and thus decreasing the dynamic disturbances at the rails.

As late as 1896, a committee of the Master Mechanics' Association, in a report on Reduction of Weight of Reciprocating Parts in Locomotives, called attention to the mutual relation between first cost and weight of reciprocating parts, with the main emphasis on the former. Now, however, with a tremendous increase in tonnage, weight of locomotives, wheel loads, etc., the question of weight has become as important as, if not more than, the first cost. The electric locomotive is now almost perfect so far as balance is concerned, as there are practically no reciprocating parts to be balanced. That is why the record of over 130 miles per hour made by an electric locomotive in 1903 has not yet been equalled by any reciprocating steam engine in either this country or abroad. The fastest time for a steam locomotive of which there is authentic evidence, made on the S. F. & W. on March 1, 1901, is 107.9 miles per hour and that for a very short run.

The speed of a steam locomotive is limited by the steam capacity of the boiler, and also by the liability of the locomotive to "jump the track" at excessive speed, for the reason that the vertical pressure on the rail due to centrifugal force of the over-balance in the driver increases as the square of the velocity regardless of what proportion of reciprocating parts weight is counter-balanced. Thus in every case there is a natural effort on the part of the wheels carrying the over-balance to rise from the rails at high speed. In addition to that, the author affirms that the over-balance in the drivers hammers the rails when the locomotive is in motion, and that rails do not crystallize but are broken by the centrifugal force of the over-balance coming at the time when the track is frozen rigid and cannot cushion the shock.

The speaker claimed for the rolled steel piston the following two advantages,—first, reducing the weight of the reciprocating parts and second, reducing the cylinder wear; in fact, he questions whether it would not be wise to rule that no locomotive (passenger at 70 miles per hour and freight at 45 miles per hour) shall show an impact on the rail due to over-balance more than 30 per cent within the static weight on the drivers. A similar rule is strictly adhered to by the Pennsylvania Lines East of Pittsburgh where no engine is allowed to show more than 30 per cent dynamic augment at above speeds. German railways allow only 15 per cent dynamic augment at high speed while the average for this country is 62½ per cent.

The author gives the Pennsylvania Railroad formula for calculating counter-balance required at the tread of a driving wheel based on the dynamic augment of 30 per cent, as well as the constants worked out by the Baldwin Locomotive Works for calculating dynamic augment for locomotives already in service. The author shows the advantage of light reciprocating parts on the axles of locomotives recently developed by the Pennsylvania Railroad and the Baldwin Locomotive Works and proceeds to the description of a new method of manufacturing pistons developed by the Carnegie Steel Company at its Homestead Car Wheel plant. The ingots are cast according to the usual open hearth furnace practice in moulds 22 in. by 22 in., about 6 to 7 ft. long. After stripping and soaking in the furnaces, they are rolled into round blooms, 15 in. in diameter and while hot, sheared into "cheeses" of the proper weight to produce the required section. The important element is the further forging and rolling work and it is very important to bear in mind that the blocks are now sheared from rolled rounds into the form of discs rather than from flat slabs into the form of squares,

as was done some time ago. This difference in procedure is the keystone of the present day success of rail steel sections and various types of wheels and is due to the fact that the outside of the ingot which according to the nature of the elements composing it, is its best part, finally becomes by this process the outside or periphery of the section while the center, naturally the weakest part, finally becomes the core and goes back into scrap.

After inspection, the discs are taken to the wheel plant. There by means of a steel dog running between two rails, the disc is transferred to a hydraulic press, the function of which is to pierce a hole considerably smaller than the rough bore desired, about half way up from the center on the axis of the disc, in order that the disc can be held between the rolls on a pin until the hydraulic pressure applied grips the piece and forging commences.

The author describes in detail the mills used and the exceptionally heavy equipment necessary to work high carbon steel into annular sections. After rolling, the piece is put through a shear which automatically trims it of the flash usually present in flat forging. In the same machine the core is punched out, thus freeing the steel of any undesirable segregation that may happen to be present after the discard from the round bloom has been made at the blooming mill shears.

An experiment was made to trace the movements of the center of the ingot during the process of manufacturing an annular section. A bar of copper 1 in. in diameter was inserted in the hole drilled through the axis of the disc while cold. The disc was then heated and worked in the usual manner. After the core had been punched out, it was split longitudinally with the copper bar. The latter was found to have varied from its original position slightly less than an inch, the maximum variation from the center line occurred about half way through the section, indicating that the steel had been thoroughly worked all the way through.

Among other things, the author takes up the question of the working of the piston against the cylinder. He states that a close investigation will show that a fair percentage of cylinders wear on the top side due in part to inferior line guides, loose crossheads and to the fact that when the locomotive is working under steam, the pressure works first under the piston rings and tends to throw the piston forward against the top of the cylinder. In order to prevent the piston from scoring the cylinder's face, the author suggests following the practice of designers of heavy stationery engines when using solid rolled steel pistons in locomotives; to cut one or more dovetail grooves in the face of the piston, insert segments of good malleable bearing metal and hammer it solidly into the dovetail grooves. This has an added advantage of forming an oil groove or pocket between the piston rings and bearing metal face. Another suggestion is two rings of bearing metal. The solid rolled steel pistons for the Pennsylvania Railroad are used with extended hollow piston rods which have the advantage of reducing the cylinder wear and simplifying lubrication.

The author states that he has made laboratory tests of a new plate ring metal which showed an "exuding" point of 1150 deg. fahr., which can be easily pinned into a dovetail groove ¼ to ⅜ in. deep and which has an average scleroscopic hardness of 8.

SOCIETY OF MECHANICAL ENGINEERS, TOKYO, JAPAN

Journal, vol. 17, Tokyo,

No. 34, September 1914

Disturbing Action of Shaft Governor (for abstract see *The Journal*, February 1915, p. 124)

The Distribution of Stress in a Tension Strap having a Circular Hole Filled with a Plug, K. Suehiro (abstracted)

Theory of Elasticity of Rods whose Center Line is a Space Curve, T. Matsumura (abstracted)

The Mechanical Transmission Gearing of the S. S. Anyomaru, C. Shiba

No. 35, October 1914

Die transversale Festigkeit der Drahtkanonen, M. Okochi (abstracted)

Influence of the End Condition of Long Columns on their Strength, T. Hishida (in Japanese)

On Design of the Volute Springs, Y. Shima (in Japanese)

Distribution of the Water Pressure in a Centrifugal Pump working with no Delivery, I. Oki (in Japanese)

THE DISTRIBUTION OF STRESS IN A TENSION STRAP HAVING A CIRCULAR HOLE FILLED WITH A PLUG, K. Suehiro.

The paper is an extension of a previous paper entitled The Distribution of Stress in Plates having Discontinuities and Some Problems Connected with it. (Published in *Engineer* in 1911).

In the present paper, the author treats mathematically the case of plane stress where the plate is not only strained in its plane but also in the direction of the normal to the plane. It is assumed that a rectangular thin elastic plate is pierced with a circular hole in its center and filled with the plug and that it is then subjected to edge traction in its plane, normal to the sides, the breadth of the plate being supposed to be sufficiently large as compared with the size of the hole so that the displacement of a distant point is not influenced by the presence of the hole. It is next assumed that the plug is of the same material as the plate and just fills the hole without exerting any initial stress on the plate. The author treats the problem by a strictly mathematical method and comes to the conclusion that an engineering structure can be partially relieved from stress concentration due to the presence of the hole by filling the hole with the plug (11 pp., 3 figs).

THEORY OF ELASTICITY OF RODS WHOSE CENTER LINE IS A SPACE CURVE, T. Matsumura.

The paper develops a general theory of elasticity of rods whose central line is inside curve, this theory being then applied to the problem of spiral springs.

In the course of his investigation the author develops the main questions governing the deformations of such rods and shows how they can be applied to the determination of the deformation of cylindrical spiral springs: first, when a spring is held at one end and subjected to tension by an axial load applied at the other end and second, when the cylindrical spring used in a shaft governor, revolves around the shaft in the plane perpendicular to it. In each case when the angular velocity is high, the elongation is considerably affected by the centrifugal force of the spring itself.

TRANSVERSAL STRENGTH OF WIRE GUNS, M. Okôchi.

The article discusses the question of transversal strength of wire guns, a problem which has hitherto been treated

with respect to one particular type and which the author attempts to treat in a more general manner. He establishes the fundamental equation for the distribution of stress in a thick, walled hollow cylinder of which the surfaces are exposed to certain external and internal radial pressures, assuming that the distribution of temperature inside the walls of the ordnance piece (although there are no precise data to support such an assumption) occurs in accordance with the Fourier theory of the conductivity in homogeneous materials and that because of the shortness of duration of the external pressure, it is stationary. He passes then to the consideration of an equation for distribution of stresses in a supposititious wire gun having no solid core and made exclusively of thin wire, and from this, to the consideration of a wire gun with an inside core for which he derives an equation showing the distribution of stress in three directions, both in the core and in the wire elements and also gives expressions for the total stresses in the wire gun at the instant of discharge. Among other things, he shows by his formula for the stress in the wire both in the stationary state and at the instant of discharge, that different states of stress can be obtained with the winding tension maintained constant and derives an expression for the winding tension giving equal tangential tensions.

He proceeds then to the consideration of the strength of large caliber wire guns of complicated structure and fully establishes the mathematical equations for stresses in such cases. Further, in order to facilitate the calculation of the strength of wire guns by his formula, the author gives a table showing the values of the co-efficients used therein. The matter is handled in a strictly mathematical manner and therefore is not suitable for abstracting.

WESTERN SOCIETY OF ENGINEERS

Journal, vol. 19, no. 10, December 1914, Chicago.

The Work and Some Accomplishments of the Forest Products Laboratory, Madison, Wis. Howard F. Weiss.

Some Aspects of the Work of the Illinois Utility Commission. Robert M. Feustel.

Coon Rapids Low Head Hydro-Electric Development on the Mississippi River near Minneapolis, J. W. Link (abstracted).

COON RAPIDS LOW HEAD HYDRO-ELECTRIC DEVELOPMENT ON THE MISSISSIPPI RIVER NEAR MINNEAPOLIS, J. W. Link.

Description of the low head hydraulic development with a total fall of about 165 ft. or an average fall per mile of 2.75 ft.

One of the most interesting features of this construction is the way the foundation is set up. Owing to the wide variety of ground encountered, a hollow structure is carried on piles so as to insure against unequal settling as much as possible. The possibility of a blowout against the structure was provided for by enclosing the whole area of the dam and powerhouse with steel sheet piling, driven to such a depth as to penetrate well into what was assumed to be impervious material, that is, impervious under the pressures which are present in this particular case. A working load of only 10 tons per pile was allowed under all of the structures except the powerhouse, such a load limit being used in order to have a closer spacing of the piles and thus insure a more uniform distribution of the loads. In driving the piles careful watch was kept of the penetration and the bearing value of the pile was figured by the Engineering News formula. At the south end of the spillway where compact clay rises to the bed of the stream, it was found impossible to drive either sheet steel piling or round piles and instead of that, concrete walls were substituted, the concrete being placed in the trenches without forms. A method of carrying on the excavation was used which involved driving the pile after the excavation was completed. This resulted in the heaving of the bottom and the distorting of the braces but the work was carried through to a successful finish by tying the bracing down to the heads of the piles already driven. This did not entirely stop the distortion and buckling of the bracing but prevented it from collapsing. Provision was made in the foundation for taking up the horizontal forces so as to prevent movement of the structure down stream. This was done partly by driving inclined piles and also by carrying out buttresses down stream between the draft tubes, each buttress resting on a cluster of 32 piles driven to refusal.

The Tainter gates used in the plant have no cross bracing. They are built up of I beams which span the opening and are attached to plate girders at the end. From the girders, struts extend to the pins which support the gates and upon which they hinge. Between the beams and the struts gusset plates are inserted instead of the usual cross bracing, the cover plates being riveted to the flanges of the I beams. Gates formed in this way will require somewhat more metal and will possibly cost slightly more than the others, but have the advantage of being less liable to damage in case they are overtopped by flood. They are made watertight on the bottoms and ends by the use of rubber belting. The hoists for these gates consist of two stands with chain drums driven by a worm gear, the worms in their turn being driven by a line shaft in one piece. The hoists are arranged for hand or electric motor operation, the latter being provided only for emergency cases where it is desired to open the gates quickly; so far, no motor has been installed.

The expected annual output from the plant as it stands (5 units) is 52,000,000 kw-hr. and 64,000,000 kw-hr. from the complete installation of 7 units. The generating units are of the vertical type consisting of Allis-Chalmers single-runner Francis turbines direct connected to General Electric alternators and fitted with roller thrust bearings and oil pressure governors. The turbine runners having a mean diameter of 8 ft. 6½ in. and a diameter over the discharge ring of 12 ft. 8 in., are set in concrete scroll cases with cast iron pit rings. The wheel gates, which control openings 54 in. high by 13 in. wide, are of the swivel type with exterior operating ring and links.

The rotating element of the machine is carried by a roller thrust bearing which rests on the upper spider of the generator, and the length of the shaft from the center of the runner to the top of the roller bearing is 21 ft. 6 in. A water lubricated lignumvitae guide bearing is carried by the upper cover plate of the turbine and an oil-lubricated guide bearing is carried by the upper spider of the generator just below the roller thrust bearing. The shaft has a flanged coupling 3 ft. 7 in. above the lower guide bearing. The lubrication of the roller bearing and the upper guide bearing is secured by a unit oiling system. The oil filter, storage tank, and circulating pump are located in the wheel pit. The motor-driven rotary circulating pump is mounted on the oil tank and forces the oil up to the bearings, the return of the oil to the filter being by gravity (37 pp., 25 figs. *d*).

MEETINGS

LOS ANGELES, JANUARY 15

A very successful meeting of the Los Angeles Section was held on January 15. Prof. Walter H. Adams read a paper on the "Diesel Engine and its Application to Southern California. The paper was of particular interest in view of the extensive oil development in Southern California, and it was discussed by Messrs. Clark, Clapp, Harris, Finkle, Gerhardt and Weeks.

MINNESOTA, JANUARY 28

On January 28, the Minnesota Section held a joint meeting with the Western Association of Electrical Inspectors which was holding its annual convention in Minneapolis. At this meeting, Charles L. Pillsbury, past vice-chairman of the Minnesota Section, gave an address on the Principles Entering into Valuation of Public Utilities and Rate Making. Mr. Pillsbury gave a very strong address and treated especially some of the fundamental principles involved in rate making and valuations of public utilities, citing from a large number of supreme court decisions as his authorities.

NEW YORK, FEBRUARY 9

At the monthly meeting of the Society in New York, held on February 9, an address was delivered by Edwin J. Prindle, of New York, a patent expert, on A Proposed System of Classifying and Digesting the Records of the Society to Render Immediately Available all Information on Each Branch of Every Subject. Mr. Prindle proposed an ambitious plan of indexing technical literature with special reference to not only properly classifying all the valuable information contained in the records of the Society, but also so digesting all papers and articles in the records that each phase of every subject treated shall be referred to.

This will, he thinks, obviate the necessity of patiently going through every paper page by page to ascertain whether the information desired is available. The plan is based on the experience of the United States Patent Office in classifying inventions in general and mechanical inventions in particular. Mr. Prindle explained the system of digesting law books in considerable detail, and pointed out the features so thoroughly tried there, which are applicable in a corresponding system for the Society's records. He showed illustrations of the record cards that would be used in the system proposed and indicated the various forms that the indexing would take for classifying different subjects.

The proposed plan was extensively discussed. In general, it met with favor, except that the majority of the discussors expressed regret that it should be limited to the works of the Society alone, whereas the plan could be made so much more useful by extending it to cover the transactions of the other great engineering and technical societies. The difficulties of a work of this magnitude were then pointed out, and much general discussion followed, notable among which was the suggestion in a written discussion from Henry Hess that the matter be laid before the Engineering Foundation, recently established in New York for promoting research work.

MILWAUKEE, FEBRUARY 10

At a meeting of the Milwaukee Section on February 10, L. G. Warren, resident Engineer, gave a lecture on the new Linwood Avenue Intake tunnel.

The paper describes the construction work done on the tunnel and shaft. The contract was executed by Joseph Hanreddy & Company of Chicago, Illinois.

The compressor plant was operated by motors from current taken from the local electric company. It consisted of a 2 stage Ingersoll Imperial type No. 10 compressor, capable of delivering 1,000 cu.ft. of air per minute and two single Ingersoll Imperial type compressors capable of delivering 700 cu.ft. of air per minute. The first compressor was used to furnish air to the drills and pumps in the tunnel and the second for furnishing air to the tunnel when it was under air pressure and also for furnishing air to the pumps in emergencies.

The method of excavation is described in considerable detail. The material encountered consisted chiefly of red clay, hard pan and brown shale, the latter requiring blasting for removal. In the completed shaft, the hoist form was made of 12 x 12 timbers. It is divided into two compartments each provided with guides for one cage. Two cages operated on a breast cable by means of an electric hoist, were in constant operation. These cages then conveyed both the in-going and out-going mules and also the laborers. A set of air locks were installed at station 0 plus 75. It consisted of one material lock and one man lock. The material lock is composed of $\frac{3}{8}$ in. boiler steel, being 7 ft. in diameter and 20 ft. long. The man lock is composed of $\frac{3}{8}$ in. boiler steel, being $3\frac{1}{2}$ ft. in diameter and 12 ft. long. It has been necessary to use these locks for one emergency, which will be described later.

All of the concrete was mixed in a one-yard Smith Mixer situated on the surface. From the mixer, the concrete is dumped into the tunnel cars and then by the cage into the tunnel where it is hauled by mules into the forms. The forms are composed of steel plates and angles with the side walls and arch forms separate. Each of these forms rests on wheels which are supported on movable rails, so that the forms can be advanced by means of the hoisting engine on the side wall form. The side walls and the arch are placed by separate operations, the side walls being placed in advance of the arch. About 100 feet of the invert has been placed adjacent to the shore shaft, leaving the remainder to be placed after the completion of the arch and side walls. The reinforcing rods in the side walls are driven 18 in. into the shale bottom, so that they may be removed by excavating beneath the side walls, and a bond secured with the reinforcing rods in the invert when the invert is placed.

The paper describes in detail the water inflow system used as well as the method of ventilation. The latter was effected by a 6 in. fan, rated at 3675 cu.ft. per minute.

For warning measures, two miners' safety lamps are constantly maintained in the heading, one suspended on the timber above the platform for the forms for concreting the side walls and one suspended on the roof timber about 8 ft. back of the face of the heading. The City's inspectors, and the contractor's men have been instructed in the use of these lamps for the detection of methane.

BUFFALO, FEBRUARY 11

At a meeting of the Engineering Society of Buffalo on February 11, C. H. Bierbaum delivered an address on Bearings and Their Lubrication. Mr. Bierbaum has been making a special study of this question for the past seventeen years and gave a very interesting lecture which was fully illustrated by drawings on the blackboard. He explained the fundamental principles connected with the design of bearings and arrangements which should be made for their proper lubrication. His address was interspersed with accounts of actual tests which have been made and troubles which have been remedied from actual practice. In addition, he explained the various formulae, etc., which have been developed in connection with this work and the concensus of opinion from the members after the lecture was, that he had presented one of the most interesting addresses so far given and one which was of great practical value to the 120 members present.

ATLANTA, FEBRUARY 12

A meeting of the Atlanta Branch of the Society was held on February 12. The meeting took the form of a luncheon at which a general discussion took place relative to the welfare of our local branch and prospects for the future. It was decided to hold these luncheons once a month in order for the local members to keep in closer touch with each other and to advance the general interests of the branch.

BOSTON, FEBRUARY 15

The Sixth Annual Joint Engineers' dinner was held on February 15 and was the first public function to be held in the new Boston City Club Building. Among the speakers were the following: His Excellency Governor David I. Walsh, Dr. Allan McLaughlin, Mr. Charles H. Eglee, Captain Robert W. Bartlett, the Presidents of the Local Engineering Schools and the Presidents of the Engineering Societies. There were about 250 in attendance.

NECROLOGY

JOHN HENRY CLARK

John Henry Clark was born in Cornwall, England, on April 7, 1859. As a young man, he served an apprenticeship as a machinist in the shops of Cooke, Rymes and Company at Charlestown, Mass., and also with the Whittier Machine Company in Boston, Mass., and afterwards became superintendent of the works of the latter company. He was also associated with Hon. Oliver Ames, formerly governor of Massachusetts, who was interested at that time in the development of an oil engine.

In 1890, Mr. Clark took a position with the Thomson Houston Motor Company which was one of the companies affiliated with the Thomson-Houston Electric Company for the purpose of exploiting the electric elevator business. This company afterwards became merged in the General Electric Company which was organized in 1892. When its power and mining department was formed, Mr. Clark was connected with it and continued in that department until his death. He was transferred from Boston to Schenectady in 1895.

Mr. Clark was a member of the Boston Engineers' Club and the Engineers' Club of New York. He died at Schenectady, January 3, 1915.

CHARLES WARD

Charles Ward was born in Leamington, England on March 5, 1841 and came to America in 1871. He had been trained as a gas engineer in England and almost his first work in America was in Charleston, West Virginia where he installed the first gas works. He later became superintendent and general manager of the company.

Mr. Ward came into prominence before the engineers of the country when the late Admiral Melville invited the makers of water tube boilers to compete for supplying the boilers of the coast defense vessel Monterey. Mr. Ward's boiler was tested in 1890 and proved so noteworthy for the length of the test under severe conditions and attained such excellent efficiency that four boilers of this type were installed on the Monterey. Mr. Ward thus has the credit of the first installation of water tube boilers on a large war vessel.

Even before this, smaller water tube boilers of a different design manufactured by Mr. Ward had been used in steam launches of the United States Navy and they have given such satisfaction that the Navy Department has continued their purchase and use to the present time.

Mr. Ward was also a pioneer in the use of screw propellers on western river steamboats in the effort to reduce waste and increase efficiency as compared with the time honored stern wheel boats, which are almost exclusively in use. Some years ago, he carried out a repetition of the famous test in England during the first half of the last century of a tug of war between a screw propelled boat and a stern wheel boat of the same power. In the later case as in the earlier one, the screw propeller showed the better results.

Mr. Ward died in Charleston, West Virginia, on January 17, 1915.

HENRY SELBY HAYWARD

Henry Selby Hayward was born at Brooklyn, Long Island, September 19, 1845. His parents moved to Elizabeth, N. J., in 1852; was educated at Rev. David H. Pierson's School in Elizabeth; entered the Novelty Iron Works at the foot of Twelfth Street, New York, in 1862, and there served a four years' apprenticeship in marine construction work and engineering.

In July 1866, he entered the service of the Pacific Mail Steamship Company and made a voyage on the steamship "Montana" through the Straits of Magellan to San Francisco. He was sent back to New York via the Isthmus of Panama and returned in July 1867, on the steamship "Great Republic," to San Francisco, via Straits of Magellan, as assistant engineer. The "Great Republic" sailed from San Francisco for Japan in September 1867, the first regular steamer on the Japan and China route of the Pacific Mail service. After several voyages between San Francisco and Hong Kong, he was detailed to service on branch lines and spent about four years' service on the steamers "Hermann," "New York," "Costa Rica" and "Arizona," plying between ports in Japan, China and Siberian coast. During that period he filled positions as second and first assistant and acting chief engineer on the different steamers.

Mr. Hayward returned home November 1872 on three months' leave after six years of continuous service, but while home he decided to resign, and entered the service of the Pennsylvania Railroad Company April 1, 1873, as machinist

in the Altoona shops. He was subsequently detailed to duty in draughting room, and in 1874 was detailed for special duty on the United Railroad of New Jersey Division, with title as assistant road foreman of engines. He was appointed assistant superintendent of motive power, United Railroad of New Jersey Division, April 1, 1875, to which the marine department was subsequently added in 1881.

On October 1, 1882, he was appointed superintendent of motive power of the United Railroad of New Jersey Division, and was also made superintendent of motive power of the West Jersey Railroad in 1883, and the Camden & Atlantic Railroad, including the ferries and floating equipment on the Delaware River, in 1884. He had supervision of the motive power and marine equipment of the New York, Philadelphia & Norfolk Railroad from January 1, 1890, until his death.

During the 80's he took out several patents, one being for an interior check valve on locomotive boilers, another for a car journal box, and still another was a cut off valve for beam engines. This cut off valve was practically adopted by all the ferries in New York Harbor.

He had been a member of the American Society of Mechanical Engineers since March 1, 1882, and of the Society of Naval Architects and Marine Engineers since May 1893. He was also a member of the Engineers' Club of New York, the Engineers' Club of Philadelphia, and the New York Railroad Club.

PERSONAL NOTES

James F. Monaghan, until recently associated with the Waltham Bleachery & Dye Works, Waltham, Mass., has opened an office in Boston, as an engineer and specialist in the engineering of processes and equipment relative to the bleaching, dyeing and finishing of cotton and linen piece goods.

James A. Gish, Jr., has become affiliated with the Nebraska Portland Cement Company, Superior, Neb., in the capacity of plant manager.

Alfred C. Nelson announces that he has opened offices in the Rockefeller Building, Cleveland, O., as consulting and contracting engineer.

William H. Smead has closed his office in the Citizens Building, Cleveland, O., and has taken charge of all mechanical work for the welfare department of the City of Cleveland, including designing new power house plant and heating plant at the new City Hospital, and mechanical improvements at the Cooley Farms.

Egbert Moxham, until recently associated with the E. I. du Pont de Nemours Powder Company, Wilmington, Del., as assistant manager of the development department, has accepted the position of general manager of the Aetna Explosives Company, New York.

George F. Murphy is now associated with the Heine Safety Boiler Company and will have charge of their sales offices at Pittsburgh, Pa. He was until recently sales representative in charge of the eastern branch office of Busch-Sulzer Bros.-Diesel Engine Company of St. Louis, Mo., with headquarters in New York.

The following members of this Society have been elected to offices in the Engineers' Club of Philadelphia: J. W. Ledoux, President; D. Robert Yarnall, Vice-President; L. H. Kenney, Secretary; J. E. Gibson, Director.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The fourth regular meeting of the Armour Institute of Technology Student Branch was held on the evening of February 4. F. L. Faulkner '15 presented a paper on the Adaptability of the 8 Cylinder V-Type Motor to the Automobile. Slides were used to show the different types. A general discussion followed the paper.

BROOKLYN POLYTECHNIC INSTITUTE

The first meeting of the Brooklyn Polytechnic Student Branch was held last October. At this meeting, Theodore B. Merkt gave a very interesting lecture on Sun Power Plants.

Another meeting of the Branch was held on November 7. J. A. Kinkead of the Parkesburg Iron Company gave a very interesting lecture on Charcoal-Iron Boiler Tubes and George Wieber talked on Diesel Engines—Their Application to Marine Work.

At the meeting on January 9, Arthur V. Farr of the S. K. F. Ball Bearing Company gave a talk on Present Day Applications of Ball Bearings.

The fifth meeting of the Polytechnic Student Branch was held on February 6. The meeting was unique in the fact that for the first time student papers composed the evening program. Three papers were presented: Ice Making by Samuel P. Blakeman; Friction Losses in Universal Joints by Murray Harris; and Present Day Locomotive Practice by Merritt Van Valkenburgh.

CASE SCHOOL OF APPLIED SCIENCE

On February 11, at a meeting of the Case School of Applied Science Student Branch, Russel C. Manning '15 gave a paper on Electrification of Steel Mills. He discussed reasons for installing the electric drive in rolling mills as against the steam drive as used formerly. It showed that though the first cost was greater, the economy of operation of large producer gas engines direct connected to the alternating current generators offset this increased first cost to such a degree that they were coming more and more into use. The method of operation of the mills when driven electrically was discussed and the fact was brought out that even in the case of reversing mills, motors were proving more effective; a few power and cost figures were given to show this. The paper was discussed by A. P. Armington, L. K. Baker and L. W. Hodons.

COLORADO AGRICULTURAL COLLEGE

A meeting of the Colorado Agricultural College Student Branch was held on January 18. Mr. Searles gave an interesting review of the article Steam Locomotives of To-Day from The Journal of January, 1915.

Professor Crain then gave a short talk on the Locomotive Testing Plant at Purdue.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on January 8, Prof. Sidney A. Reeve, formerly of Worcester Polytechnic Institute gave a lecture on Heat and Work. Professor Reeve by clever and interesting analogies gave a very clear conception of heat and entropy. He compared our oceans of water to the oceans of temperature surrounding us toward which all temperatures fall. Further comparisons with the mechanics of motion, movement of celestial bodies, molecular motion and vibration proved interesting and extended the vision on the subject.

CORNELL UNIVERSITY

The Cornell University Student Branch held a meeting on January 22, at which Elmer A. Sperry, President of Sperry Gyroscope Company, Brooklyn, N. Y., gave a lecture illustrated with lantern slides and experimental demonstrations on the theory of the gyroscope, its present applica-

tions and the widening field for its use. In naval use, it proves its worth as a compass, as a stabilizer for the ship itself or for telescopes, horizon finders or the like, for recorders of pitch, roll and angle of yaw. It has similar uses on aerial craft.

KANSAS UNIVERSITY

On January 21, at a regular weekly meeting of the Kansas University Student Branch, O. H. Ruth gave a report of his visit of last November to the plant of the Western Electric Company at Hawthorne, Ill. His talk was general and by means of a chart he showed the layout of the entire factory and the arrangement of the buildings and pointed out the advantages of such an arrangement. Some stress was laid upon the shipping facilities and the ware-housing methods of the company. He spoke also of the advantages offered by the company to its employees in the way of protection of health, physical exercise, social amusement, etc. Quite a lengthy discussion followed among the members of the Senior Class who visited the plant on their fall inspection trip.

Dale S. Mills reported on the Industrial Engineering magazine. He chose for his subject the refrigerating plant of the Sargeant Wharf Station of the Quincy Market Cold Storage and Ware-house at Boston, Mass. Most of his discussion was on the new 1000 ton compressor used at this plant, which is the largest compressor ever built, and spoke somewhat in detail of the construction of the parts for this massive machine.

At a meeting held on January 28, at the home of Dean P. F. Walker, Prof. C. C. Young of the water analysis department of the University of Kansas gave a lecture explaining the causes and effects of bad water used for feed water in boiler plants. He also showed how boiler scaling could be prevented by different means of water softening and cited instances where such prevention has been successful, and pointed out the fact that any boiler plant can save money by installing a water purification plant instead of using the old means of removing scale with tools for that purpose, except in a few very rare cases where soft water is available. Not only does the installation of such a plant save on labor, but very materially saves on the life of the boiler. A good discussion followed by Dean P. F. Walker and Prof. A. H. Sluss, Superintendent of the power plant at the University of Kansas.

LEHIGH UNIVERSITY

At a meeting of the Lehigh University Student Branch on December 10, W. F. Roberts, superintendent of the Lehigh Plant of the Bethlehem Steel Company gave a paper on Ordnance.

W. J. Bailey, special student at the University read a paper on Naval Architecture.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Mechanical Engineering Society held its first meeting since the mid-year vacation on February 17. This was the first lecture meeting for some time, the most of the activities of the Society this year having been confined to trips to various large factories.

Harry Gay of the Stone and Webster Engineering Corporation gave a most interesting talk on The Equipment of the new Technology. Mr. Gay confined himself more to the administration connected with the equipping the new buildings than to the pieces of apparatus and the like which are being installed. His talk showed very well the vast amount of work which must be done to avoid errors in the final product when so much is at stake. His remarks also showed very well the nature of the work in an up-to-date drafting office.

OHIO STATE UNIVERSITY

At a meeting of the Ohio State University on January 14, W. A. Converse chemical director of the Dearborn Chemical Company of Chicago addressed the members of the branch on Treatment of Boiler Feed Waters. As the engineer is usually more or less familiar with the scale forming action of water, Mr. Converse limited his talk to the corrosive action alone, which until quite recently had received little attention. He stated that waters containing no scale forming substance were not necessarily harmless, but might be highly corrosive. He cited a case where the analysis indicated the water to be very satisfactory but that it corroded or dissolved the pipe lines through which it passed so badly that it was necessary to replace them once every six months.

The speaker discussed briefly the physical and chemical properties of water and traced its passage from the vaporous condition in the clouds through the atmosphere, the surface of the earth and the lower strata of materials, and told just what substances were absorbed, and also discussed several typical analyses of boiler feed waters and indicated how the engineer is likely to be deceived.

The causes of pitting and some of the modern theories of electrolytic action were spoken of, and lantern slides illustrating experiments which tended to prove these theories were presented.

PENNSYLVANIA STATE COLLEGE

At a meeting of the Pennsylvania State College Student Branch on January 18, the following officers were elected: W. D. Garman, president, V. D. Longo, vice-president and J. L. Sprenkle, secretary.

STEVENS INSTITUTE OF TECHNOLOGY

On Wednesday, January 16, a party of eighteen students under the guidance of the Stevens Engineering Society visited the Otis Elevator Company's plant at Yonkers to inspect the various departments. The society was very fortunate in obtaining the privilege of visiting this plant through the kindness of the Vice-President of the company for according to rule, inspection of the plant is forbidden.

On February 10, the society conducted an inspection trip, to the National Biscuit Company's plant.

SYRACUSE UNIVERSITY

The first important meeting of the new semester of the University of Syracuse Student Branch was held on February 9. Plans were made for conducting a series of "Personal Efficiency" lectures to be under the direction of W. C. Dexter, chairman of the branch and which are to be given at each of the bi-weekly meetings. In addition to this, they have prepared a short series of lectures on the Working of the New Workmen's Compensation Law in New York State, on the History of the Electrical Industry in this Country and on Banking.

The Student Branch voted at that meeting to challenge the Senior Electrical Engineers to a debate in the near future. Two questions will be submitted to them for their choice: Should Military Training be Compulsory in the Colleges of this country and Should Arbitration in Labor Troubles be Compulsory?

On February 12, an illustrated lecture on Submarines was delivered to the entire student body of the Engineering Department by G. E. Furbush, Secretary of the Student Branch. The history of submarine boats was traced from the crude efforts of Symons in 1747 up and through the present time. Much detailed information regarding modern practices in this country and abroad was presented. It is hoped that it may be possible to use a more complete abstract of this paper in an early issue of The Journal.

THROOP COLLEGE OF TECHNOLOGY

At the regular meeting of the Throop College of Technology Student Branch on January 28, Paul Weeks, representative of the Baldwin Locomotive Works and a member of the Society, gave a very interesting talk on some of his experiences as an engineer. He pointed out some of the difficulties which he met with and showed how he overcame them.

UNIVERSITY OF COLORADO

In the January issue of The Journal a brief account was given of a meeting of the Student Branch at the University

of Colorado, Boulder, at which a lecture was given by Charles M. Hampson of Denver. The lecturer discussed the square deal in engineering and the ethics involved in the work of the mechanical engineer, and it is believed that the following extracts from the lecture will be of general interest to members of other sections.

Mr. Hampson said that while the engineer of the past had to know his machine shop and foundry practice, his drawing board and steam plant, to-day he must also understand ions and ohms, amperes and resistances and must be a fair all 'round civil engineer as well. The chances are that the men who are backing an undertaking do not know the first principles of engineering and the mechanical engineer is naturally the custodian of their money and is largely responsible for the success or failure of the undertaking. It is to his advantage to have a reasonable, practical working knowledge of the essential details of engineering in its various departments.

The speaker quoted statistics with regard to salaries of engineering graduates which indicate that the average mechanical engineer receives sufficient compensation so that he can well afford to give of his best.

Speaking of the square deal, he said: Square, according to Webster, means "forming a right angle, true, upright, honest, just." Deal means a bargain or understanding. Could we have a better watch word? A right bargain. Remember this: A square deal means a true understanding.

There are no mistakes in the engineering profession; it is the only profession that does not recognize the word. A trained engineer has no excuse for a misconception. Engineering is an exact science so far as it goes. The engineer should not attempt to go further than his knowledge. When in doubt he should stop.

We all know when we are in the right and when we are not right. We all know good work, square work, and we must insist upon that sort of work or none.

In tearing down an old house in Milwaukee some years ago surprise was expressed by the workmen at the standard size of the timbers. The 4 × 4s were actually 4 in. by 4 in. and the 2 × 6s really were 2 in. by 6 in. How many houses built in these later years can show such measurements of dimension stuff?

If it were now desired to use timber in construction work that was full dimension it would be necessary to place the order with the mills well in advance and pay an additional price of at least two dollars per thousand over the regular price. Think of it; you specify a certain sized piece of timber and are then compelled to use a piece from 10 to 20 per cent smaller. How about the factor of safety? The only way to get a square deal is to specify absolute sizes and make allowance in the cost sheet.

During the past fifteen years it has been my duty to handle a great many yards of concrete work, in engine foundations, power plant walls and other work in connection with engineering projects. In almost every contract the greatest watchfulness has been necessary to insure the honest reinforcement of the structure. For some inexplicable reason the average concrete worker seems to consider the reinforcement used a sort of joke. I have seen men attempt to utilize three strands of barbed wire for a ¾ in. twisted bar. In many cases where 1 in. square bars have been distinctly specified an attempt has been made to substitute round bars with only three quarters the area. Many cases of failure in dams and retaining walls have been traced to such insufficient reinforcement.

My attention has been called by Professor Lawrence to the following ethical questions concerning the work of the engineer which I consider of the greatest importance.

Has a mechanical engineer a right to buy, invest in or sell stock in any company or corporation which may be directly or indirectly affected by his position, knowledge or influence?

Has a mechanical engineer a right to accept a commission either directly or indirectly on any material, equipment, machinery or supplies in use by the company he represents which could possibly affect his judgment?

Has a mechanical engineer any right to give out information regarding the plant to which he is giving his services to personal friends which might possibly act to the detriment, ultimately, of the concern that is employing him?

If we consider these questions at all seriously we must admit that we are confronted with a question of morals rather than ethics. The question then becomes: "Do you propose to use all your knowledge in the building up of the business that you are paid to exploit or will you use your profession to advance your own personal and private interests?"

A square deal in engineering means to me, first, a square deal to the person or company acting in the capacity of employer. In order to give this square deal, in the judgment of many of the leading engineers of the country, it is very much better that the graduating engineer should have no personal interest of any description whatever in the stock of the company or the earnings of the individual employing him. Personally I have, at times, purchased or otherwise acquired stock in companies employing me, but, in every case, I have found that it was a mistake on my part to become so interested. Self-interest is one of the most important factors to deal with and an engineer must be able to act absolutely without prejudice in order to render the best services possible in return for the compensation that he receives.

Now about giving out information concerning your work to outsiders. Here is a question that requires very careful discrimination. A man has a perfect right to feel proud of his work. Who of us do not? We are naturally anxious that our light should not be hid under a bushel; that our friends should know and appreciate what fine work we are doing, but even here let us bear in mind that our first duty is to the man that writes out the pay checks. It is so easy sometimes to start a conflagration and so terribly hard to put it out. Use most careful discrimination and if there is any doubt in your mind as to the propriety of mentioning business matters take my advice and—don't.

"Above all to thine own self be true; it must follow as the night the day thou canst not then be false to any man."

UNIVERSITY OF ILLINOIS

At a recent meeting of the University of Illinois Student Branch the following officers were elected for the next semester: R. C. Maley, president; L. Eslick, vice-president; E. B. Stout, secretary and D. E. Miller, treasurer.

This branch has just completed a very successful semester's work. Six meetings were held in which lectures and discussions of the following nature were given: Short Cuts in Computation, by Professor Goodenough; The Quarry St. Station of the Edison Commonwealth Company, Chicago, Ill., by E. C. Pierce; The Balancing of High Speed Engines by E. S. MacPherson; Coal Hauling Machinery, by L. Eslick and Saw Mill Machinery, by O. C. Hutchinson.

The big event of the semester was the "Open House" given by the society on the evening of October 23. The object of it was to bring the under-classmen of the University into closer touch with the engineering side of college life. All the laboratories, including the machine, forge and wood shops were thrown open to inspection while the different branches of mechanical engineering were being explained, demonstrated and illustrated by slides in the various departments. Souvenirs consisting of "I" buttons turned out by the wood shop, paper weights by the forge department and M. E. watch fobs of an artistic pattern molded in the foundry were presented to the visitors. In the steam laboratory each visitor was given a chance to make himself a set of indicator cards from the various steam and gas engines while the latter were running under full load. In one corner of the big steam laboratory was a complete power plant in operation which furnished power for the

Seroco ventilating fan, and the dynamo which generated current for the large "A. S. M. E." automatic flashing sign. An ice machine in operation was demonstrated in another part of the laboratory and apparatus of various kinds were operated and explained to the visitors. There were 2000 people present.

UNIVERSITY OF KENTUCKY

At the December meeting of the University of Kentucky Student Branch, Prof. E. F. Farquhar spoke of the advantages of the engineer who has an extensive vocabulary at his disposal over the engineer with a limited vocabulary. He spoke in general of English being a prerequisite to the engineer.

At a meeting on January 14, Minott Brooke spoke at length of extravagances of the young engineer and introduced several methods of economy among resident engineers.

UNIVERSITY OF MAINE

At a meeting of the University of Maine Student Branch on January 22, Mr. Keppel Hall who is installing the Taylor system of Scientific Management at the Eastern Manufacturing Company's plant at Brewer, Maine, gave a talk on Scientific Management. The four main divisions that he emphasized were as follows: A close analysis of the work; close analysis of the workmen; putting the right man on the right job; making the management realize that the installation of Scientific Management was not for the sole purpose of profits for them.

UNIVERSITY OF MICHIGAN

At a meeting of the University of Michigan Student Branch on February 11, Wallace W. Tuttle was elected as chairman and M. S. Manwaring as secretary and treasurer of the Branch.

Prof. H. C. Anderson gave a general talk in which he mentioned several of the important branches of engineering a graduate mechanical engineer might possibly get into and some pertinent facts in connection with each of them and some good advice to the members.

UNIVERSITY OF MINNESOTA

The regular February meeting of the Minnesota Student Branch was held on February 11. Professor Shipley spoke on scientific shop management. He discussed the old military, the new Taylor and other systems now in use in various manufacturing establishments such as the Brown and Sharpe, the Tabor, and the Ford plants. He also took up in detail the various methods of compensating workmen.

UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch on January 28, the following officers were elected for the second semester: L. L. Leach, chairman; Troy Russell, secretary and treasurer; P. R. A. Nolting, corresponding secretary. A governing committee consisting of Prof. H. Wade Hibbard, honorary chairman, Prof. G. D. Newton, Stanley Goodman and J. C. Squires was appointed.

A special business meeting was held on February 5. At this meeting the terms of membership which were offered by the St. Louis Engineers' Club were accepted. The Club offers to members of student societies the privilege of Junior Membership at one-half the usual rates for initiation fee and annual dues. In addition to create interest among the student members, free associate membership carrying with it remission of initiation fee and dues for one year is offered to the student who shall present the best paper before the technical society of which he is a member.

The Engineers' Club in order to coöperate further with the student members and extend its field of usefulness offers to suggest speakers who would be willing to address student societies, to print in its May or June bulletin the names of members of student societies who desire to secure summer employment and to print in its Year Book a list of student societies and their officers. Further, the Club offers to participate annually in one joint meeting arranged by a student society or a group of coöperating societies, to grant to the student members the facilities of its Library in exchange for a similar privilege to its own members in available university libraries, and to make an appropriation from time to time to assist a student in the making of an original research provided the recipient of such financial aid shall have the endorsement of the faculty of the institution with which he is connected and the approval of the Executive Committee of the Club. In such cases, the Club reserves the right to exclusive publication of the results of the investigation in its own Journal of Proceedings. The Club agrees to invite whenever possible, the members of the student societies to go with them on various excursions which it may have.

The resignation of the present corresponding secretary, P. R. A. Nolting was accepted. I. O. Royse has been elected in his place.

UNIVERSITY OF NEBRASKA

On January 12, at a meeting of the University of Nebraska Student Branch, L. F. Shedd of Chicago gave a very interesting lecture on the birth and progress of the Safety First and Prevent Injury Movements. He told how the railroad employees were taught the principles of the movement, and used stereoptican slides and motion pictures to show many of the careless practices of the employee and trespasser and their correction. Statistics were given to bring out the effects upon loss of life and limb that the movements are having.

At a meeting of the Branch on February 2, Dr. J. Stanley Welch, a graduate of the University of Nebraska and one of the greater medical and surgical authorities in the central west, gave a very interesting and practical lecture on First Aid to the Injured. He brought out very clearly those things which are of prime importance and the order in which assistance should be rendered to obtain the best results. Following the lecture, he gave a demonstration upon one of the students of the first aid methods of treatment of the most common injuries. The demonstration included the removal of a foreign substance from the eye and its treatment until a doctor could be obtained; bandaging and putting splints on a fracture; stopping excess loss of blood; treatment of a wound; artificial respiration; how to make and sterilize a bandage and the making of splints and many similar things which any one is liable to be called upon to do at any time.

EMPLOYMENT BULLETIN

Note: In Sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

041 Mechanical engineer for manufacturing plant employing 1200 men. Thorough technical training, some experience in machine shop work and experience in executive capacity. Location Massachusetts.

042 Concern manufacturing small electrical motors in quantities wants draftsman or clerk experienced in the standardization of product parts as well as tools; must be familiar with drafting room organization and systematic recording of standards. State age, references and salary. Name confidential, apply by letter.

043 Chief engineer charge of power plants and equipment, including four or five power houses, boiler plant, electric power station, etc. Location Delaware.

046 Mechanical engineer, experienced in soap factory construction and management, for position in vicinity of New York. Name confidential.

047 Four first-class, highly efficient engineers; the minimum salary, $150 and expenses; positions will necessitate the men being on the road approximately seventy-five per cent of the time. Work consists of making power plant examinations, investigations, boiler tests, reports and recommendations. Prefer men with college education if possible, pleasant personality and tactful, as there will be constant call to handle difficult situations. Applicants must be familiar with boiler room economies and able to handle and conduct boiler tests, instructing the local men in such a way as to place the plant on the highest possible base of efficiency.

053 Young engineer in power plant work, steam engineering, and testing, for position with New Jersey concern.

054 Three draftsmen for service with a large mining company in Chili, South America. Two men must be first-class designers familiar with layout and detail work connected with a large milling and smelting plant. Third good steel designer. Must be unmarried and sign an agreement for three years. Salary starts day of departure from New York and all expenses paid to Chili and return. Living conditions at the plant are very good; climate temperate, pleasant and healthful. In application state age, experience, references and salary expected.

056 Firm of engineers and contractors having offices in New York and Chicago desires to add to present line agency for turbine or similar equipment.

061 Mechanical engineer for shop in middle west. Must have had practical shop experience and understand general machinery repairs, knowledge of boilers and engines and proper speeds and feeds of machine tools; also some knowledge of dies for pressing hot work. State age, experience, reference and salary.

MEN AVAILABLE

C-1 Associate-member, graduate engineer, six years teaching and four years general engineering experience desires position for the coming academic year in mechanical department of a technical school.

C-2 Junior, Stevens graduate, age 30, six years experience, desires position with contracting or constructing engineering firm, consulting engineer or architect.

C-3 Associate-member, technical graduate with broad experience in foundry, pattern shop, machine shop, drawing office and design, desires position of responsibility along similar lines. At present designing engineer for large machine tool concern. Eastern location preferred.

C-4 Member, age 39, married, with broad and thorough manufacturing experience from apprentice to agency manager in a large engineering corporation manufacturing steam and producer gas engines, producers and transmission machinery; with firm for nine years in the capacity of draftsman, designer, estimator, mechanical engineer, salesman and agency manager, also experienced in efficiency engineering, correspondent and advertising, desires position.

C-5 Junior member, technical graduate, 13 years railroad experience in motive power department as machinist, draftsman, boiler inspector, machine shop, car, roundhouse and general foreman, desires position as master mechanic or mechanical engineer.

C-6 Mechanical engineer with broad and varied experience available as purchasing engineer or as technical assistant in purchasing office.

C-7 Member, technical graduate, 12 years experience as designer, assistant superintendent and sales engineer with three well known engine building concerns, would consider responsible position with large engineering firm. At present employed.

C-8 Junior, graduate, broad experience in concrete materials, three years highway experience, now leveler, wishes position in foreign country.

C-9 Mechanical engineer, age 37, Stevens graduate 1900, experienced and resourceful, at present mechanical superintendent and assistant manager of large manufacturing plant desires position.

C-10 Member, technical graduate, wide training and experience in design of power plants and machinery, construction, maintenance and operation, purchasing engineering material, executive charge of all consulting engineering work, including building construction of all kinds, desires position as works manager or superintendent.

C-11 Junior, mechanical engineer, M. I. T. graduate, five years manufacturing experience, at present superintendent and purchasing agent of small concern, desires similar position in East with large firm preferably metal drawing and stamping.

C-12 Graduate engineer, six years experience factory maintenance and equipment work, desires position.

C-13 Member, technical graduate, with extended and unusual experience in shop, factory and power plant design, construction, equipment and operation, desires connection with high grade concern where the requirements call for engineer of ability and experience.

C-14 Junior, technical graduate in mechanical and electrical engineering, ten years experience in design, construction, operation and maintenance of power house and substations, high voltage electric design, piping design and layouts, etc., and building designs, desires position as power engineer, assistant superintendent of large mill, or designing engineer for large engineering firm or contractor.

C-15 Superintendent familiar with latest methods in machine shops and manufacturing plants, capable of demonstrating the output of machine tools and other equipment and getting the maximum production, can design tools and devise methods of producing interchangeable work at low cost.

C-16 Technical graduate, age 32, ten years experience factory engineering, including estimating, drafting, planning and economical production through cost control, desires position as superintendent, assistant to manager or factory engineer.

C-17 Superintendent or assistant, 11 years experience in executive capacity; thoroughly conversant with modern machine shop methods, expert designer of tools and labor saving devices. Exceptional experience in planning economical methods and qualified to handle manufacturing problems to increase production. Expert in pressed steel and punch press work.

C-18 Engineer, Stevens graduate, age 31, unmarried, capable manager, excellent designer, experienced writer of specifications, has just completed supervision of several large manufacturing plants, desires position as chief engineer for firm of industrial engineers and architects. Especially familiar with South, location immaterial.

C-19 Man with tool room and designing experience and familiar with metal working machine tools, special machinery for quantity production, tin can and paper container manufacture, is open for a position in the middle west. Can offer an improved design of a medium sized machine for manufacture.

C-20 Associate-member, technical education, age 31, experienced in shop, drawing room, as erecting foreman, has had charge of engine and boiler tests and with experience as tool designer on small work, desires position with consulting engineer or as salesman. Salary secondary consideration. Location immaterial.

C-21 Junior member, age 29, married, 12 years experience in design and construction of Diesel oil engines (European type), high grade automobile machinery and industrial plants, desires position.

C-22 Member, age 34, M. I. T. graduate, married, for past six years with leading engineers and architects in the East, designing steam power plants, heating and other piping systems and inspecting construction and equipment, at present employed as superintendent on construction and equipment of large mill and power plant, desires position along similar lines.

C-23 Member, age 33, with wide experience in design and construction of railway equipment, including modern steel passenger cars and trucks for heavy electric traction, desires position as assistant chief engineer or in similar capacity in charge of design or construction work along similar lines.

C-24 Junior member, University of Michigan graduate in mechanical and electrical engineering, age 29, unusual experience in efficiency work and design. Has held positions as superintendent, manager, efficiency engineer, and in charge of design. Some sales experience.

C-25 Junior, Cornell graduate, age 25, two years experience in fuel engineering and boiler testing, desires position in testing or experimental department of engineering concern. At present employed.

C-26 Member, graduate engineer with wide experience in efficiency engineering, also design and superintendence of light, heat and power plants, desires position with consulting engineer, architect or private concern. At present employed.

C-27 Member, graduate mechanical engineer, age 39, 20 years experience various engineering fields, inventive and executive ability, at present treasurer and general manager of engineering concern, desires to connect with responsible concern.

C-28 Member, technical graduate with 16 years railroad experience in motive power department as machinist, draftsman and mechanical engineer, desires similar position, or one as assistant superintendent, assistant superintendent of motive power, or motive power assistant to general manager or vice-president. Location immaterial.

C-29 M. I. T. graduate in mechanical and electrical engineering, age 32, married, broad and practical experience in power plants, locomotive repair shops and textile mills. Experience and ability could be applied in organization requiring man for chief engineer, production manager, electrical-mechanical or efficiency engineer, or for similar productive position.

C-30 Junior member, age 28, graduate mechanical engineer, five years practical experience, last two and one half years engineer of tests of large automobile company, desires position as assistant superintendent or engineer.

C-31 Mechanical and electrical engineer, 14 years experience in power plant and factory engineering, operation, maintenance and appraisal, also in handling men, systematic and economical operation, purchasing of equipment and material, recent experience in rubber and chemical works, desires position as works manager or supervising engineer of a manufacturing or industrial plant.

C-32 Junior, age 38, sales engineer, broad experience in handling high grade mechanical specialties, acquaintance in manufacturing and engineering fields, desires to represent manufacturers in east and middle west. At present employed.

C-33 Member, graduate M. I. T. in mechanical engineering, age 39, married, experienced in manufacture of ordnance-rifled arms, shell and ammunition, design and construction of drydocks—wood, stone and floating, pumping plants, power houses and shops; acid and electrolytic refineries; wire and cable plants; reinforced concrete and general building construction with complete electrical and mechanical equipment for same; nine years general and seven years consulting engineering; position to be executive, superintendent or engineer of construction. Location preferred, Eastern Canada.

C-34 Junior, graduate mechanical engineer, age 26, over four years experience in power machinery and power station work including general inspection work on large hydro-electric power house construction; familiar with reinforced concrete and structural steel construction; considerable experience as draftsman, desires position on plant layout work or in the field. Location immaterial.

C-35 Lehigh University graduate in mechanical engineering, three years experience in design, shop work, superintending, construction and installation; can produce results at handling men, now maintenance engineer of factory employing 800, desires position with manufacturing, engineering, consulting or contracting firm.

C-36 Mechanical engineer, age 29, seven years practical experience in designing and drawing up specifications, also assistant engineer in superintending construction of power plants, water works, etc., desires position. At present employed.

C-37 Graduate M. I. T. in mechanical engineering, two years experience in maintenance of power equipment, plant and designing new factory building with large manufacturing concern, two years inspecting reinforced concrete and steel structures with irrigation project, familiar with reinforced concrete design, desires position with construction firm, or power and plant department of manufacturing concern.

C-38 Associate, age 33, college and technical education, seven years experience in charge of engineering correspondence and estimating, desires position as assistant to consulting engineer or to executive of corporation with good chance for advancement. Location New York or vicinity.

C-39 Graduate mechanical and electrical engineer, experienced in design and construction of machinery, building, manufacturing, systematizing, accounting, refrigeration, desires position in New York.

C-40 Member, sales engineer located in New York, good correspondent and estimator, broad acquaintance in manufacturing, engineering and expert field, has handled successfully well known accounts in New England and Eastern States, desires to negotiate with manufacturer wishing a reliable representative in New York who will accept the responsibility for the management and results.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

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W. P. C.

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